California Environmental Protection Agency

AIR RESOURCES BOARD

QUALITY MANAGEMENT BRANCH

STANDARD OPERATING PROCEDURES

FOR

THE VERIFICATION/CALIBRATION AND CERTIFICATION OF PRIMARY AND TRANSFER LOW-FLOW STANDARDS

Standards Laboratory SOP 004

Revision 2

MONITORING AND LABORATORY DIVISION

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California Environmental Protection Agency

AIR RESOURCES BOARD

Standard Operating Procedures (SOP) Approval

Title:	Verification/Calibration and Certification of Primary and Transfer Low-Flow Standards
SOP:	004, Revision 2
Section:	Quality Assurance Section
Branch:	Quality Management Branch
Division:	Monitoring and Laboratory Division
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Quality Assurance Section

Quality Management Branch

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Quality Management Branch

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Verification/Calibration and Certification of Primary and Transfer Low-flow Standards

1.0 Introduction

This procedure will provide National Institute of Standards and Technology (NIST) traceable verification, calibration, and certification processes for low-flow measuring devices used as primary and transfer standards. Candidate standards are tested against a working standard traceable to the NIST via a Manufacturer Intermediate Standard (MIS). Examples of low-flow measuring devices that can be tested include the Allicat MFM and MFC, Alborg MFM and MFC, Porter MFC, BGI DeltaCal Primary flow standards, BGI TetraCal Primary flow standards, and Chinook Engineers (FTS) Primary standard. Flow transfer standards are evaluated from 0 to 100 mass flow (sccm, slpm) and 0 to 20 volume flow (lpm, ccm). These flow standards are used to support a number of air monitoring programs, some of which are listed below.

- Gaseous Criteria Pollutants
- Particulate Matter Pollutants (PM10, PM2.5)
- Toxic Air Contaminants
- Hydrocarbon Pollutants

This procedure will determine the candidate's low flow primary or transfer standard's ability to accurately and precisely measure flow.

2.0 Regulatory Requirements

- Title 40 Code of Federal Regulations (CFR), part 50 App J and L - Reference Method for the Determination of Particulate Matter as PM10/PM2.5 in the Atmosphere.

- U.S. EPA, Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program (EPA-454/B-08-003)

3.0 Summary of Method

3.1 The Standards Laboratory employs two identical flow calibration systems traceable to NIST. These working standards are laminar flow elements (LFE)-based flow standards named molblocs. Differential pressure, temperature, and thermodynamic properties of dry clean air are used by a control unit (molbox1) to calculate the flow rate.

3.2 The candidate instrument is connected via a Teflon line to the working flow standard where the display reading from the candidate instrument is directly compared to that of the working flow standard. These flow measurements are evaluated statistically to determine the flow characteristics of the candidate instrument.

4.0 Summary of Changes to Previous Version

4.1 Original version: December 14, 1999

4.2 Revision 1: August 25, 2003

4.2.1 Changes:

- Incorporated laminar flow element procedure, Section 12
- Added Method History, Section 19.

4.2.2 Revision 2: October 4, 2012 (initiated)

Changes:

- Replaced Quick Basic\DBIV Instrument Management system (IMS) with a Visual Basic Macros\Microsoft Excel\Microsoft Access Instrument Management system.
- Added electronic PDF file record keeping.
- Reformatted to meet new SOP requirements.
- Deleted Method History, Section 19.
- SOP number changed from 5721 to 004.

5.0 Definitions

- Calibration (Service code C) - establishes a correction factor to adjust or correct the output of a candidate instrument. This is determined through a single comparison between the candidate flow instrument

and the Standards Laboratory's reference flow standard at varying flow points. This type of calibration assumes that the flow measuring device is used to measure flow and not used adjust flow. The correction factor must be used to correct the candidate instrument output. If an adequate coefficient of determination (R2) is developed from comparing the candidate device to the reference standard ($R2 \geq 0.999$), the calibration test is considered valid.

- Certification (Service code FC) - establishes traceability of a candidate flow transfer standard to the NIST traceable primary flow standard. The certification of a flow transfer standard requires the results of four calibrations to meet criteria established by the Standards Laboratory. Certifications are performed when the flow measuring device is used to measure a flow rate or calibrate another flow device. The output of the candidate flow standard must be adjusted using the resultant correction factor from the four calibrations. If an adequate coefficient of determination (R2) for each test is developed from comparing the candidate device to the reference standard ($R2 \geq 0.9999$), and the slope of each calibration is within ± 1% each other, the certification test is considered valid.

- Verification (Service code V) - establishes comparability of a candidate primary flow standard to the Standards Laboratory's primary flow standard. The verification of an instrument requires the results of one calibration to meet requirements established by the Standards Laboratory. Instrument output is not corrected based upon the results of the calibration. Verifications are performed when the flow measuring device employs fundamental units to measure flow rate. Examples would be a BGI DelaCal primary flow standard and Chinook FTS. If an adequate coefficient of determination (R2) is developed from comparing the candidate device to the reference standard ($R2 \geq 0.9999$), the verification test is considered valid.

- Transfer Standards – a transportable device or apparatus that is capable of accurately measuring air flow.

- Primary Flow Rate Standards – a gravimetric, volumetric displacement device capable of accurately measuring gas flow rates with an accuracy of 0.15%.

- NIST - National Institute of Standards and Technology
- SFN - Standard Failure Notification
- Candidate – Device under test (DUT)
- Molbloc – L: Laminar flow rate measuring standard
- Molbloc – S: Volumetric flow rate measuring standard
- Tare – "Zeroing" the molbox pressure transducers at the upstream or downstream pressure to eliminate the zero error in the measurement of the differential pressure across the molbloc.

6.0 Personnel Qualifications

6.1 Before new personnel perform this procedure, one or more weeks of training from Standards Laboratory staff is required. Subsequent to this, new personnel need to be able to demonstrate competency in performing this procedure without any assistance.

7.0 Health and Safety

7.1 Do not over-pressurize the equipment. Adhere to manufacturer's pressure specifications when setting up test.

7.2 Make sure the equipment's power cord wiring and power button are in good condition before applying power.

8.0 Cautions

8.1 Care should be taken when inserting the quick disconnects into the molblocs.

8.2 **DO NOT** drop the Molblocs. The internal components can be damaged.

9.0 Interferences

9.1 Avoid the over-pressurization or under-pressurization of candidate flow devices. Operating a flow device outside its input pressure specification

window can lead to erroneous data and or damage.

9.2 Avoid kinked or bent Teflon lines. Bent Teflon lines can restrict flow which can compromise a calibration.

9.3 Allow guest instruments to warm-up for approximately 30 minutes after powering on before initiating a calibration.

9.4 Do not over torque fittings. An over torqued fitting can lead to leaks. Always use torque wrenches to tighten fittings.

9.5 Allow airflow to stabilize for a minimum of 5 minutes after setting flow points.

10.0 Evaluation Criteria

Calculations:

Flow rate formula: $\text{Flow Rate [kg/s]} = \frac{(P1 - P2) * P(P,T) * R * h}{n(P,T) * 6 * L}$

- P1 = upstream pressure [Pa]
- P2 = downstream pressure [Pa]
- $P(P,T)$ = gas density under P,T conditions [Pa]
- $P = \frac{P1 + P2}{}$
- n(P,T) = dynamic gas viscosity under P,T conditions [Pa*s]
- R = flow passage radius [m]
- h = gap between piston and cylinder [m]
- L = length of laminar flow passage [m]

10.1 Verification

- Verifications consist of a single 5 point comparison against a primary flow calibrator.

- For a verification to be valid, the regression results of the comparison must comply with the following criteria:

    1. Squared correlation coefficient (R^2) of 0.9999 or greater.
    2. The slope must be within 2 percent of the expected value.
    3. The intercept must be less than 1 percent of full scale value of the candidate's flow standard

10.2 Calibration

A calibration is composed of a single test run at 5 points which yields a slope and intercept. This slope and intercept are used to correct the candidate's standards display. The candidate's linear regression results must have a R^2 of 0.999 or greater.

10.3 Certification

A full certification requires 4 consecutive test runs, each performed on a different day. This practice checks the stability of the flow rate measuring device.

- For a valid certification:

    1. Each test must result in a R^2 value of 0.9999 or greater.

    2. The relative standard deviation (RSD) of the four most recent slopes must be less than 1%.

    3. The relative standard deviation (RSD) of the four most recent intercepts must be less than 1%.

    4. The percent of change from the current slope and the previous slope must be less than 1%. If this criterion is not met, an additional test is performed on a different day. Additional test are conducted until the RSD criteria for slope and intercept are met; provided that each test R^2 value is ≥ 0.9999.

When all certification criteria are met, the mean of the four slopes and intercepts are used to develop the calibration relationship that is used to correct the guest display to the true flow rate at standard conditions (760 mmHg @ 25°C).

Certified flow transfer standards are traceable to NIST and carry a certification period of 12 months.

11.0 Equipment and Supplies

11.1 Working NIST Traceable Flow Standards:

- Molblox1Control Unit SN 840
- Molbox1 Control Unit SN: 705
- Molbloc - S: 1E1-S Sonic Nozzle SN: 4098 (2LPM)
- Molbloc - S: 2E2-S Sonic Nozzle SN: 501 (20LPM)
- Molbloc - S: 1E2-S Sonic Nozzle SN: 536 (40LPM)
- Molbloc - L: 5E1- L Laminar Flow SN: 2773 (50CCM)
- Molbloc - L: 1E2- L Laminar Flow SN: 2764 (100CCM)
- Molbloc - L: 1E4- L Laminar Flow SN: 2736 (10LPM)
- Molbloc - L: 3E4- L Laminar Flow SN: 2739 (30LPM)
- Molbloc - L: 1E5- L Laminar Flow SN: 6450 (100LPM)
- Molbloc - L 5E1- L Laminar Flow SN: 2123 (50CCM)
- Molbloc - L: 1E2- L Laminar Flow SN: 6448 (100CCM)
- Molbloc - L: 5E2- L Laminar Flow SN: 2172 (500CCM)
- Molbloc - L: 5E3- L Laminar Flow SN: 2276 (5LPM)
- Molbloc - L: 1E4- L Laminar Flow SN: 6477 (10LPM)
- Molbloc - L: 3E4- L Laminar Flow SN: 2215 (30LPM)
- ML- 800 -10: 5 - 500 sccm Primary Flow Standard
- ML- 800 - 44: 500 – 50,000 sccm Primary Flow Standard

- 107.001 Ohm Simulator PN: 401232
- Dry Clean Air (House Air)
- Teflon (PTFE) Tubing
- Control Company, Model: 4048/4127 NIST Traceable thermometer
- Porter MFC Control Box, Model PCMI4
- Molbox1/Molboc-L-S Flow Calibration System, NIST Traceable
- JB Industries Vacuum Pump

- Torque wrench model Ch-150 adjusted to 47 in.-lb.: 7/16 and 9/16 inch
- Molbox1/ Molbloc Terminal Operational Manual
- COMPASS for Molbox1 Flow Calibration Software User's Manual

12.0 Flow Rate Test Procedures

12.1 Turn on candidate standard. Allow a minimum of 30 minutes to 1 hour of warm-up time.

12.1.2 Turn on Molbox1/Molboc-L-S Flow Calibration System. Allow a minimum of fifteen minutes to warm-up.

12.1.3 Turn on computer workstation located in the flow calibration room.

12.1.4 Double click on the "Compass for Molbox" icon on the desktop. See Figure 1.

Figure 1

12.2 System Leak Test

12.2.1 For System Leak test, refer to the Molbox1/Molbloc Terminal Operational and Maintenance Manual Section 3.2.4.3.

12.3 See Section 18 to determine the setup connection required for the type of flow device being tested.

12.3.1 Click "Run" on the pull down menu. See Figure 2.

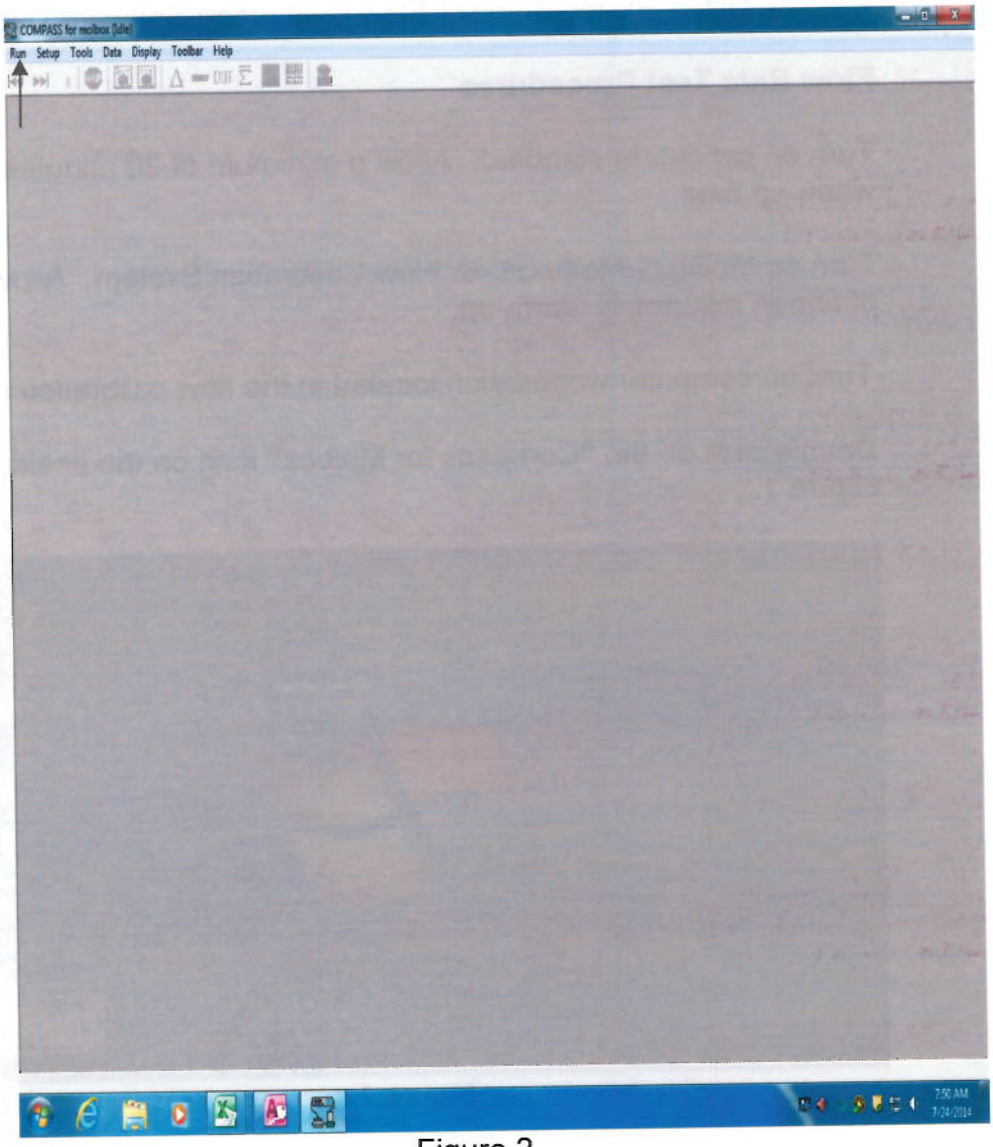


Figure 2

12.3.2 Click on "Run Test". See Figure 3.

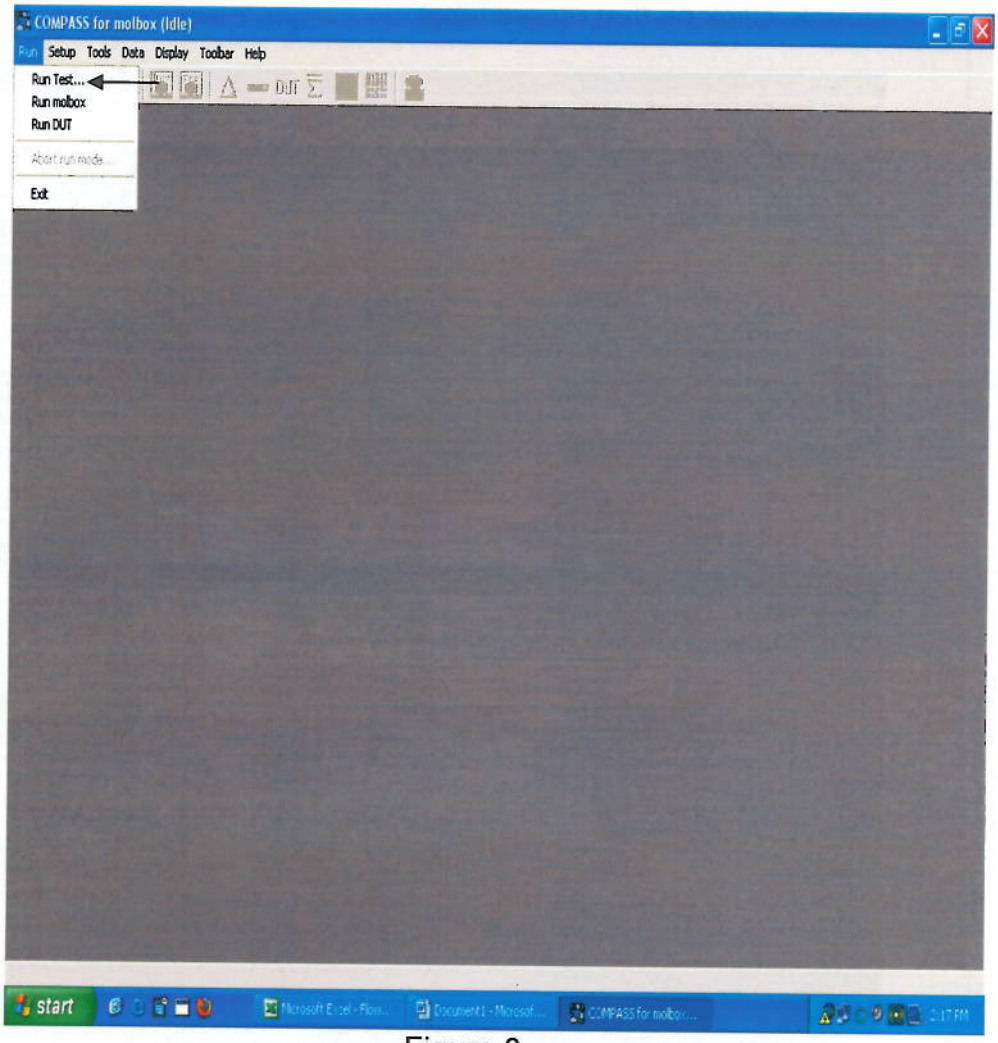


Figure 3

12.3.3 Using the scroll bar (Figure 4), scroll down to the record label that matches the model and flow range of the candidate flow standard. Double-Click on that record label.

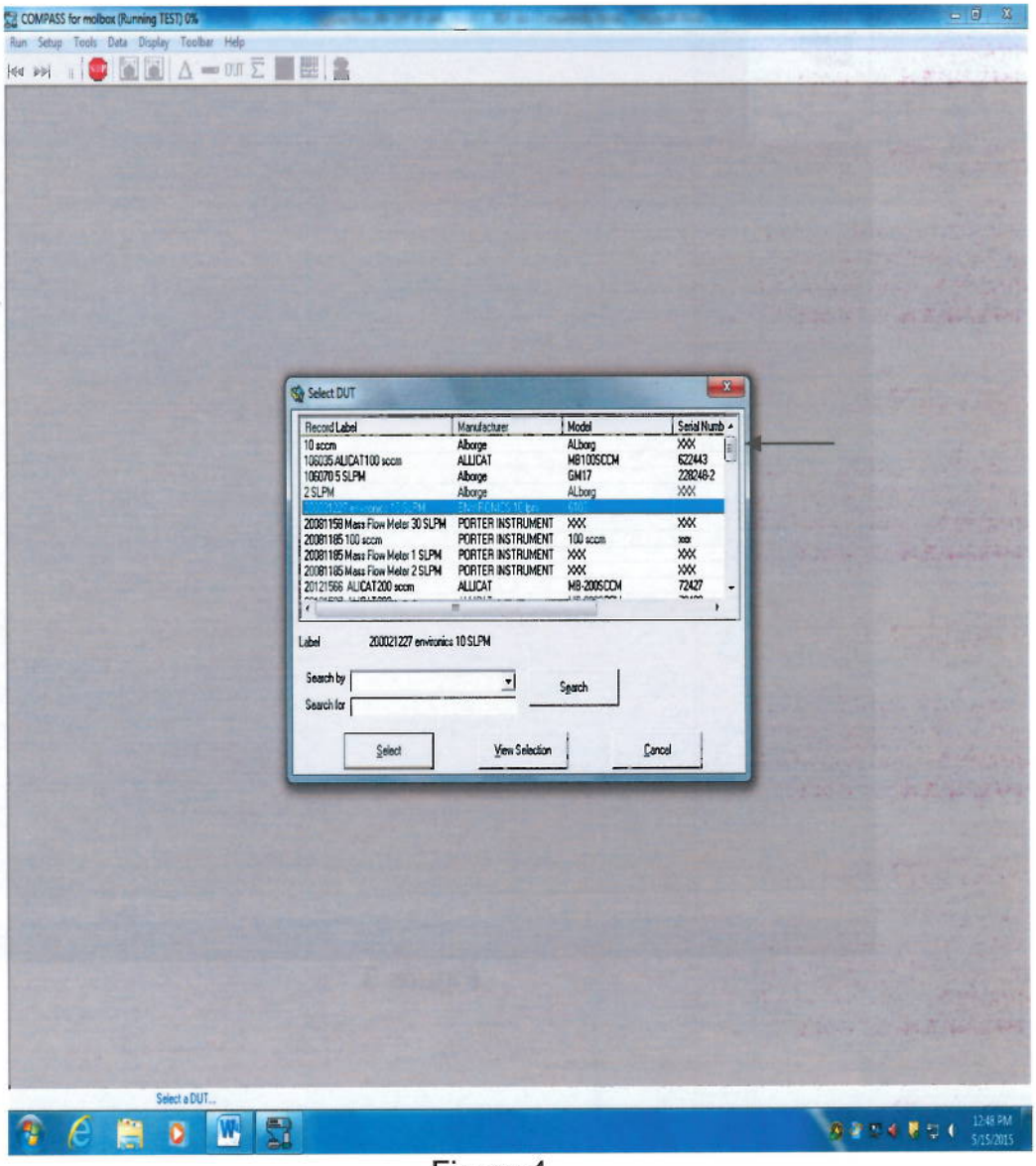


Figure 4

12.3.4 Under the "Test Label" column, highlight the "7 X 35 Measurement Test" then click on the "OK" button. See Figure 5.

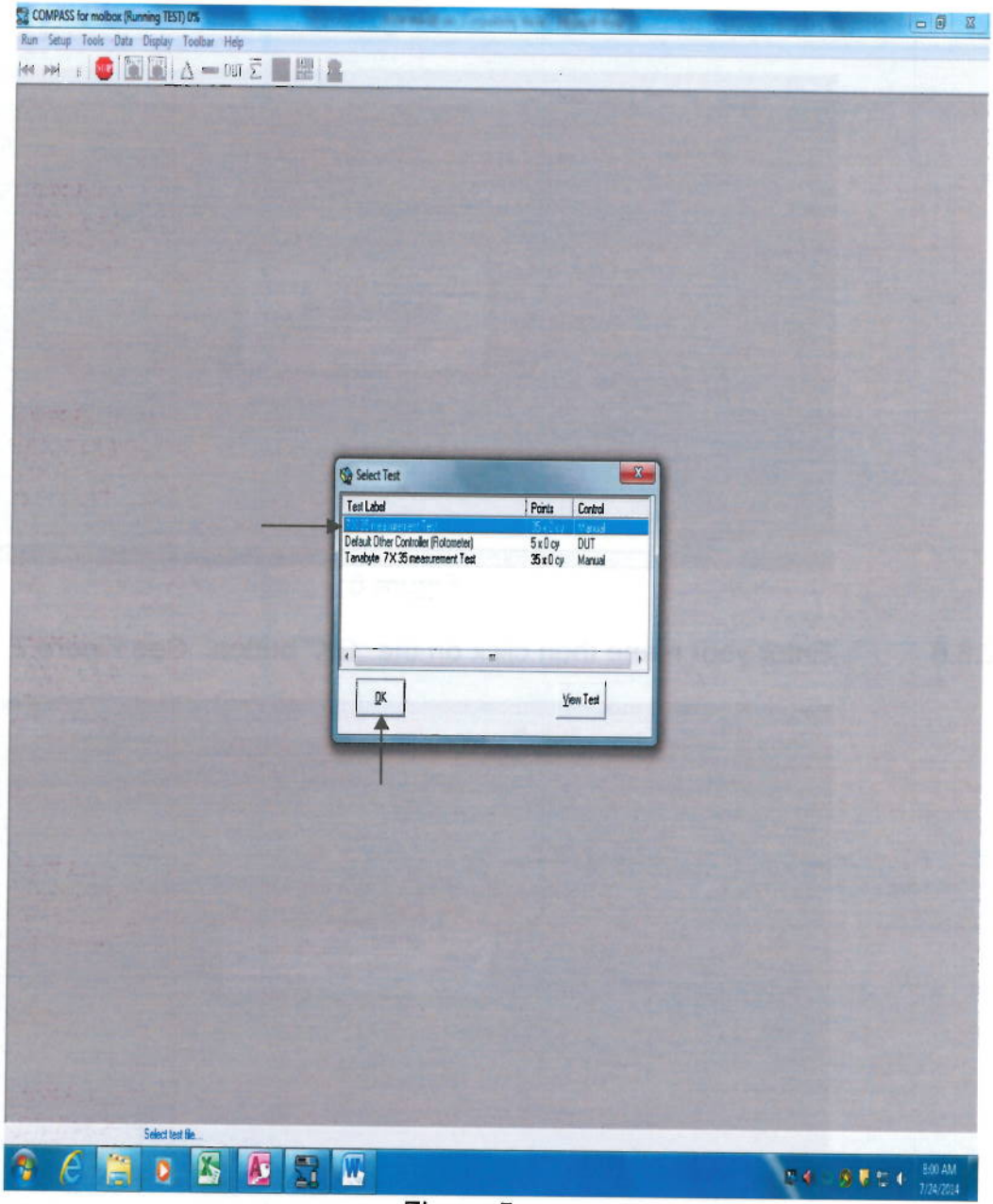


Figure 5

12.3.5 The "Flow Control Setup" window is used if you want to use the internal mass flow controllers. This window allows you to select which MFC to use. This procedure does not employ the internal mass flow cotrollers. Click on the "OK" button. See Figure 6.

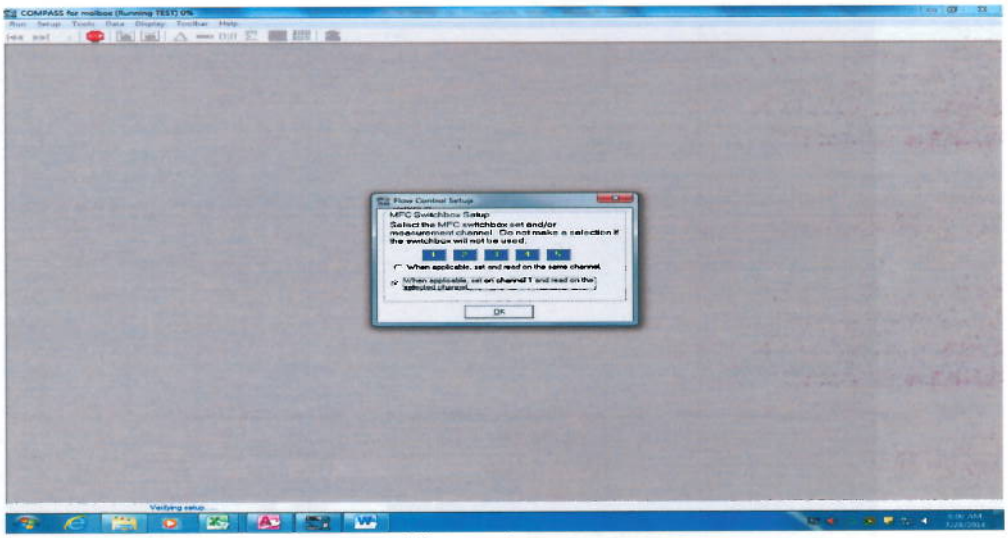


Figure 6

12.3.6 Enter your name then click on the "OK" button. See Figure 7.

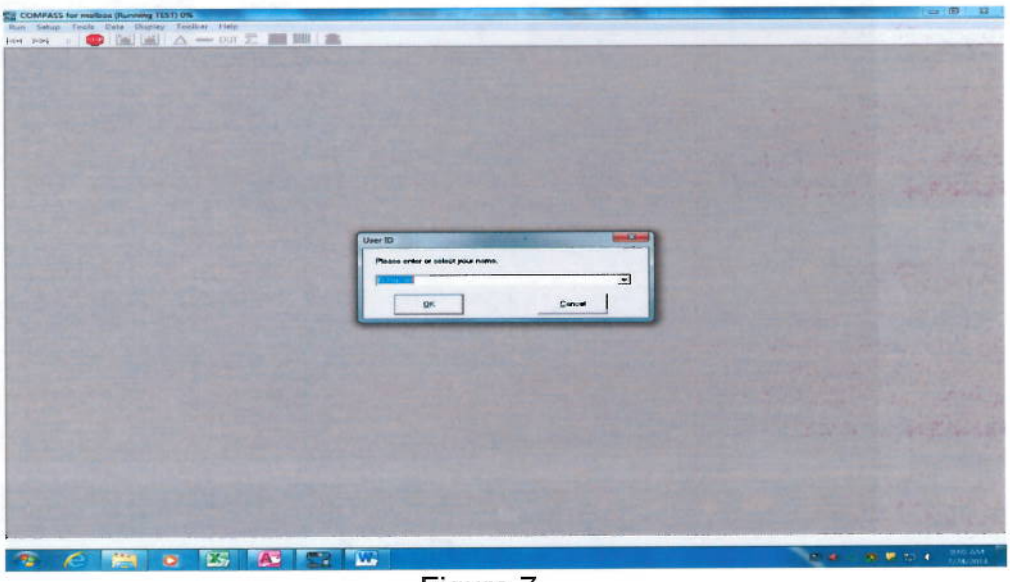


Figure 7

12.3.7 Select the Molbloc reference standard that the candidate flow standard is connected to. Your options are: A, B or A+B. See Figure 8.

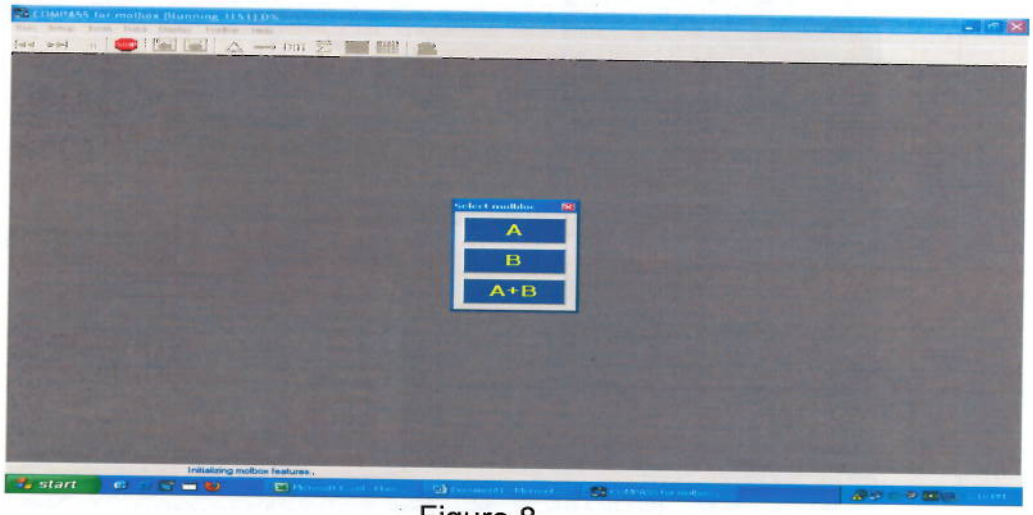


Figure 8

12.3.8 Click on the "OK" button. See Figure 9.

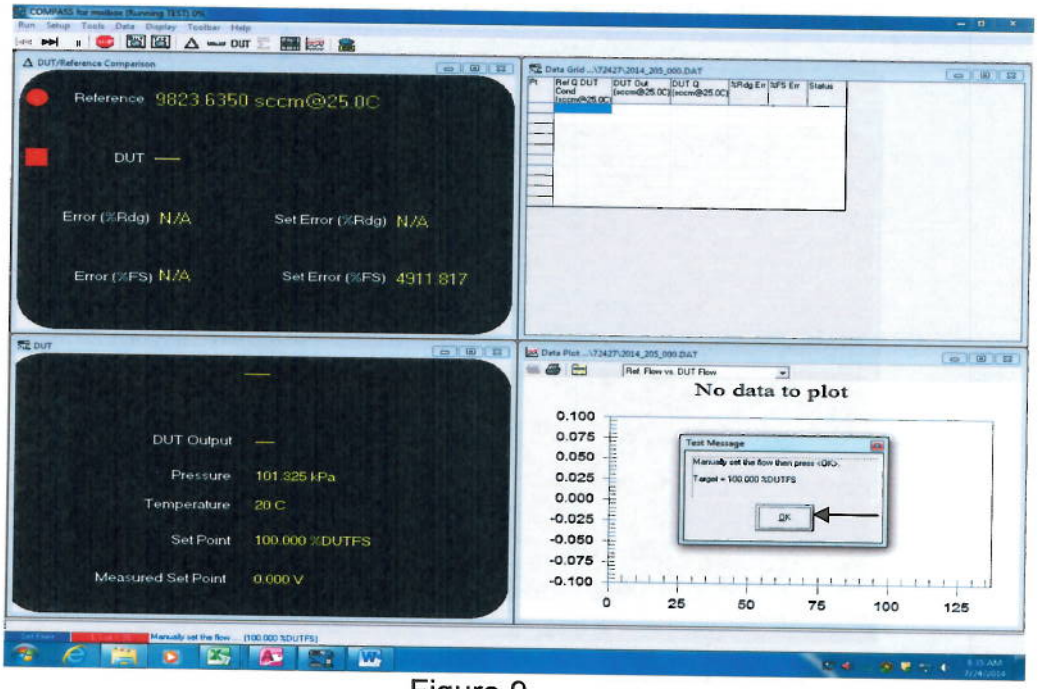


Figure 9

12.3.9 Click on the "Tare" button. See Figure 10.

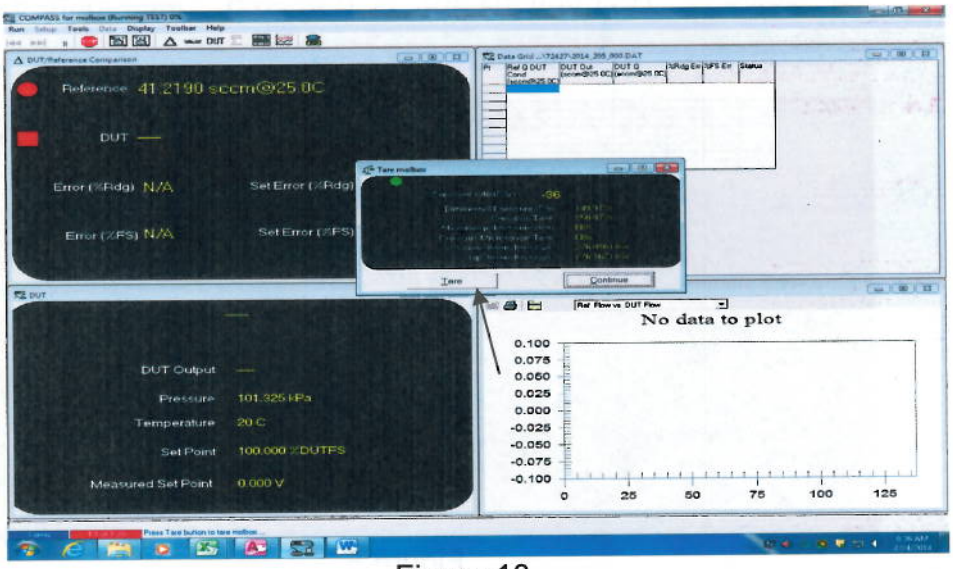


Figure 10

12.3.10 Monitor the status bar. When the status bar indicates that the Tare is complete click on the "Continue" button. See Figure 11.

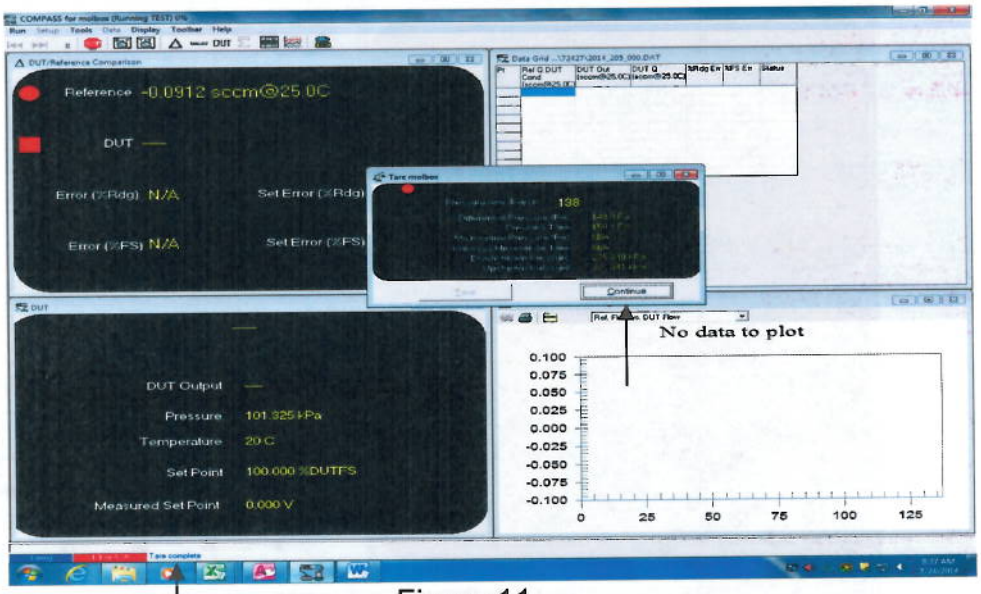


Figure 11

12.3.11 All Compass software test profiles are setup to begin each test at fullscale or at 100%. Enter the flow rate indicated on the candidate's display into the "DUT Output" text box. See Figure 12.

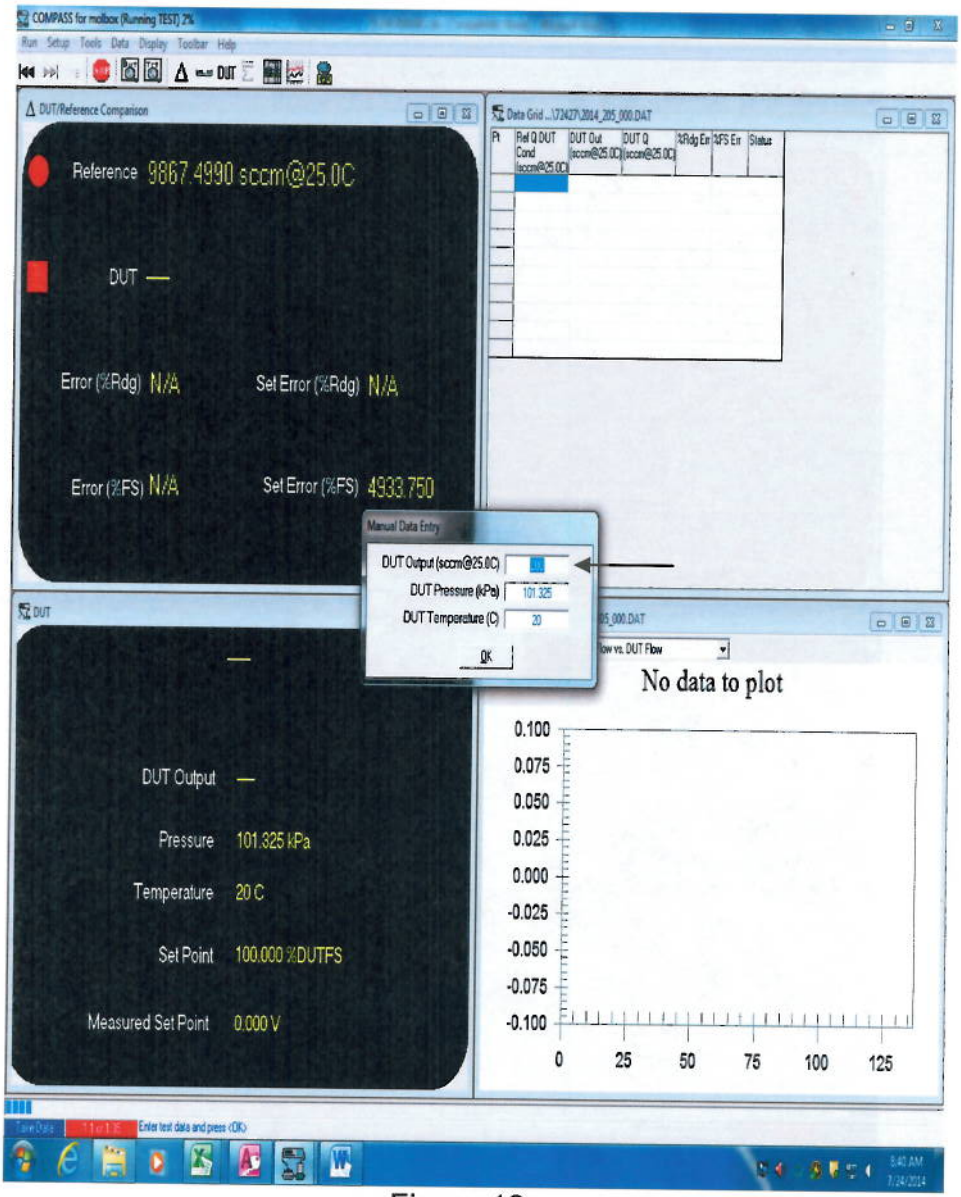


Figure 12

12.3.12 Enter the room pressure (located on the display of the Fluke PPC3 pressure calibrator located on the workbench against the east wall in the flow room) into the "DUT Pressure " text box. See Figure 13.

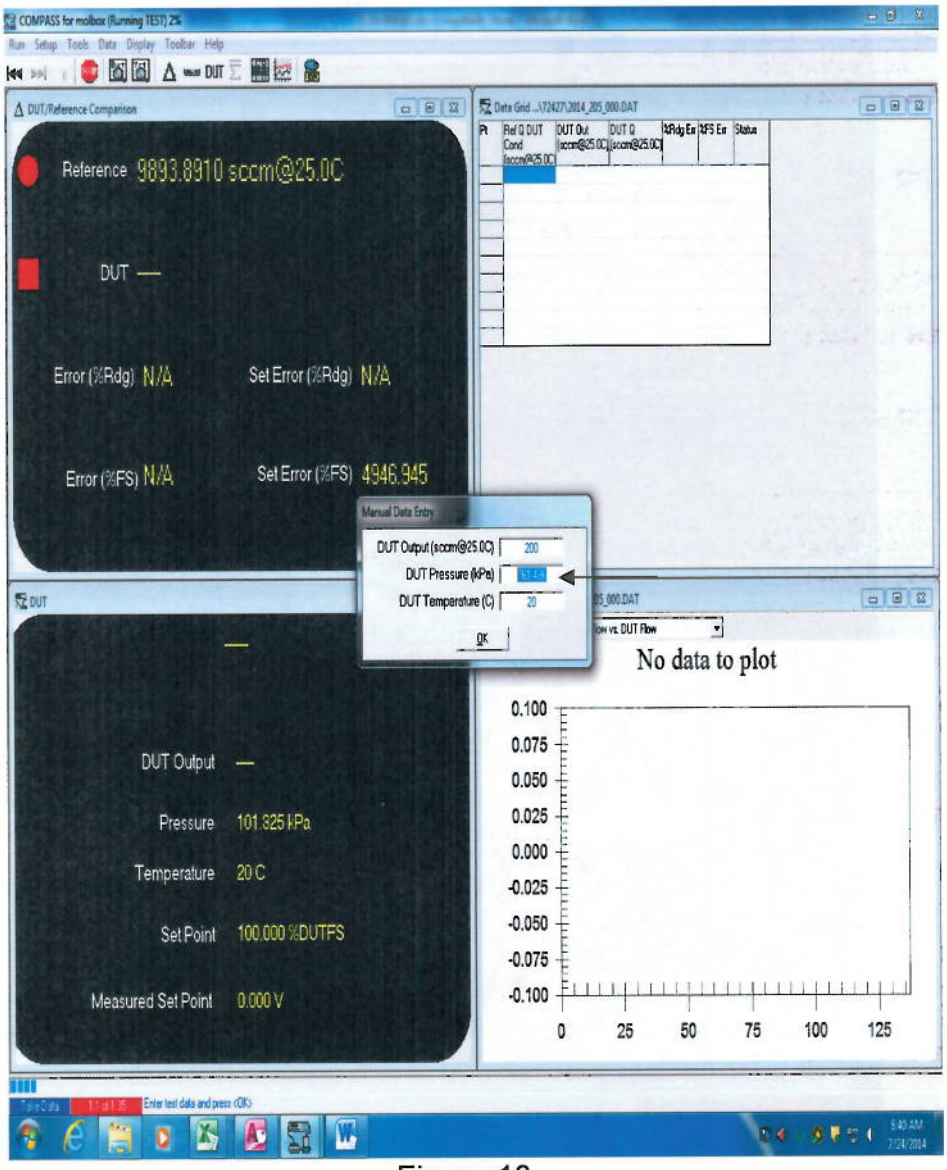


Figure 13

12.3.13 Enter the room temperature (located on the north wall of flow room) into the "DUT Temperature (C)" text box. See Figure 14.

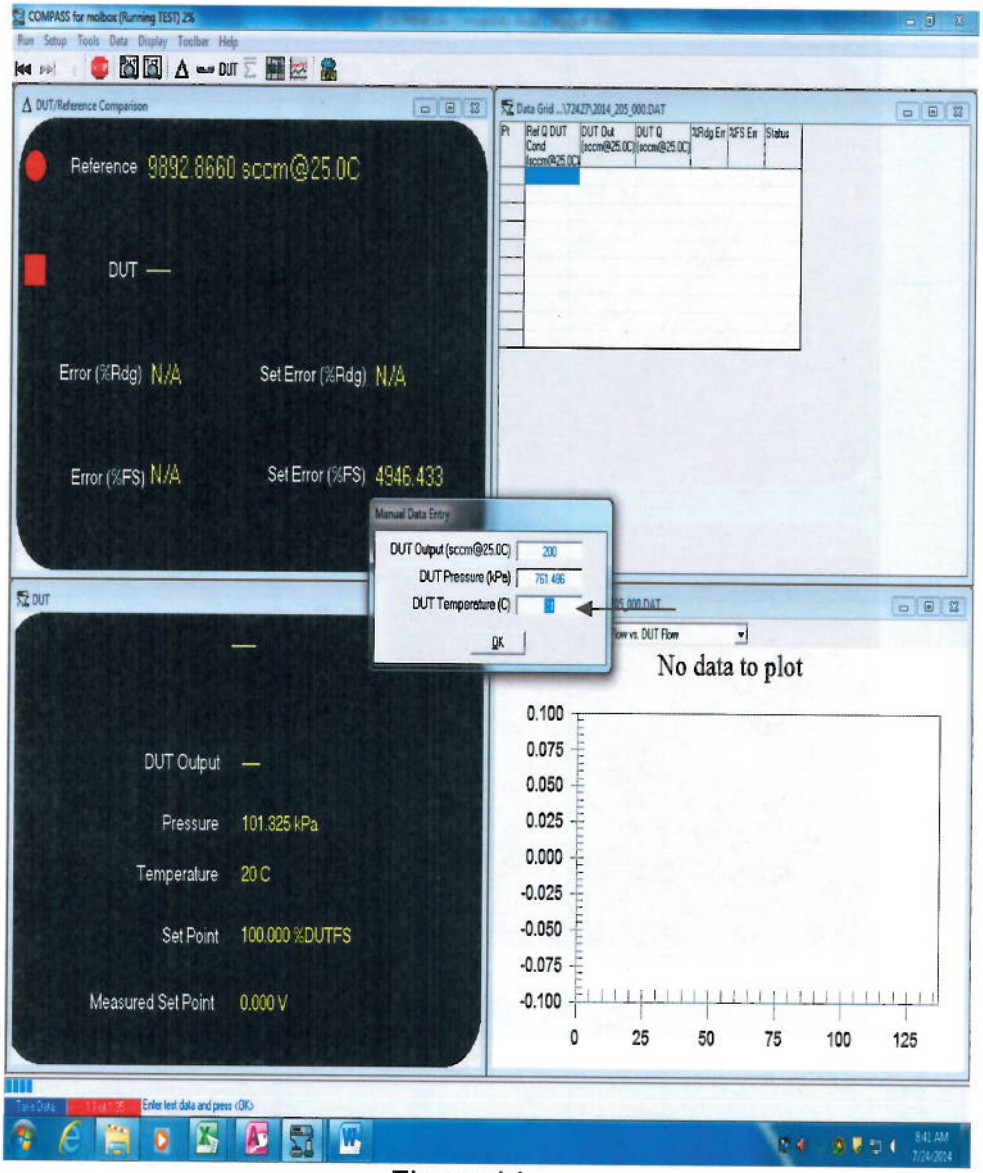


Figure 14

12.3.14 Click on the "OK" button. See Figure 15.

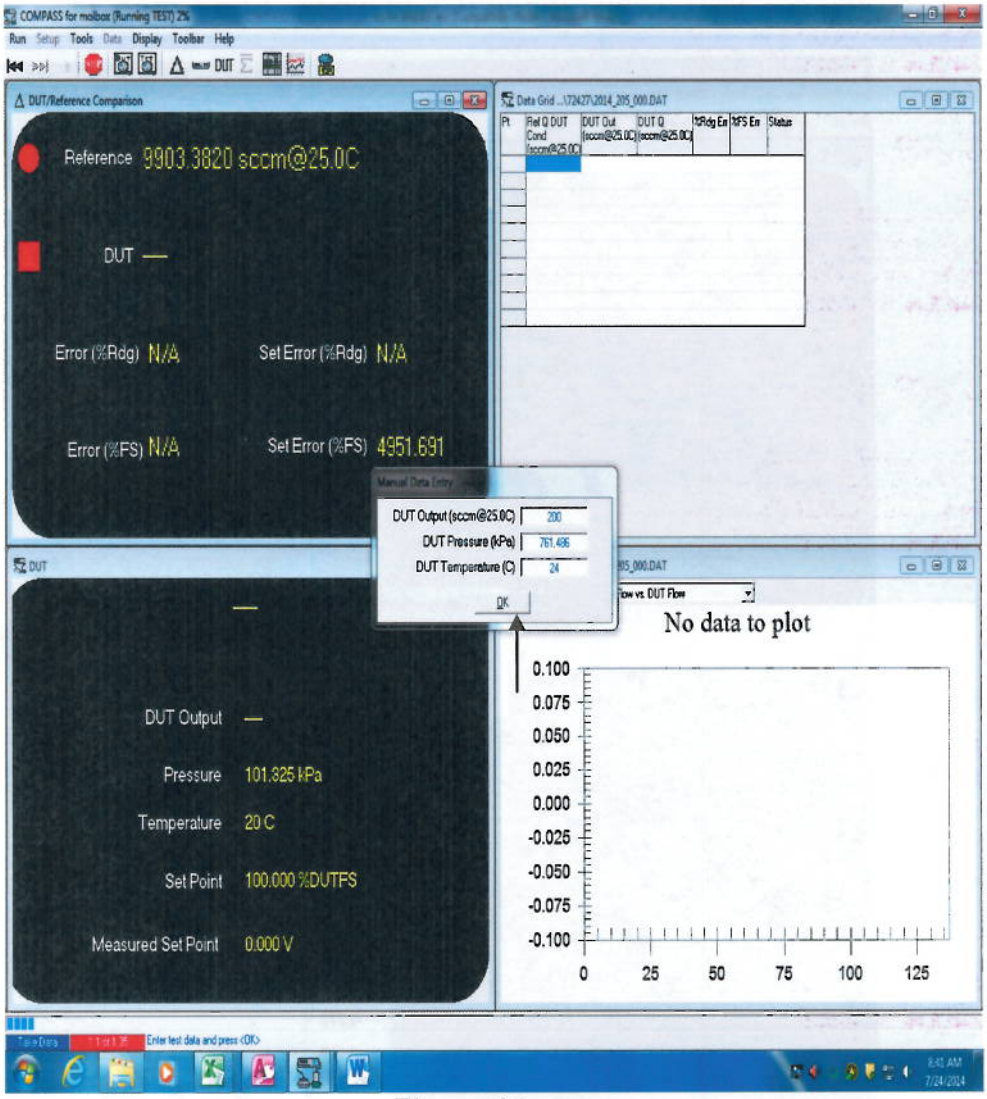


Figure 15

12.3.15 The flow test procedure described in sections (12.3.15 to 12.3.21) is utilized for Calibration, Certification and Verification tests. Certification of new devices or recertifications will require the process to be performed a minimum 4 times to generate the required information. A calibration and verification may only require the test 1 time unless there are issues. See Section 13.1.8.

NOTE: It is important that the client understands how the flow device is being used in the field. The service code is evaluated to determine the criteria that will be employed in order to decide whether a candidate flow standard will pass or fail the comparison test. See Section 5.0 for a complete definition of each service code. When possible, the standards laboratory staff will verify the service code using previous service request information or by contacting the client via email or phone.

In this flow test procedure, the Compass software test profile allows for 7 measurements at each percent of scale setpoint (100%, 75%, 50%, 25% and 12.5%) for a total 35 measurements. Before each measurement is taken, a "Test Message" window will pop-up with an "OK" button. See Figure 16. The "OK" button allows the tester time to insure that the Reference" flow reading is stable before recording a measurement. This window also allows the tester time to change the percent of scale setpoint and for the reference flow to stabililze at the new percent of scale setpoint. Allow a minimum of 5 minutes between each setpoint before taking measurements.

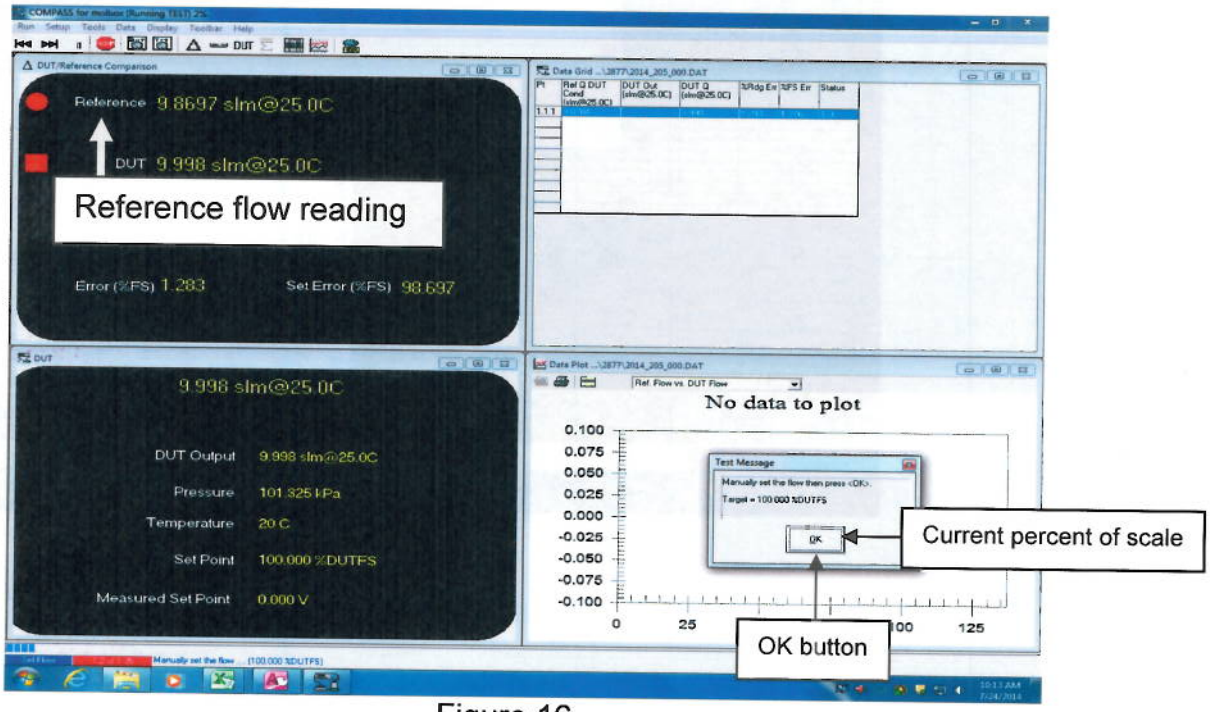


Figure 16

12.3.18 The "Test Notes" window will pop up after thirty seconds that will allow you to enter notes relating to the performance, custom setup information etc. Click on the "OK" button when finished. See Figure 17.

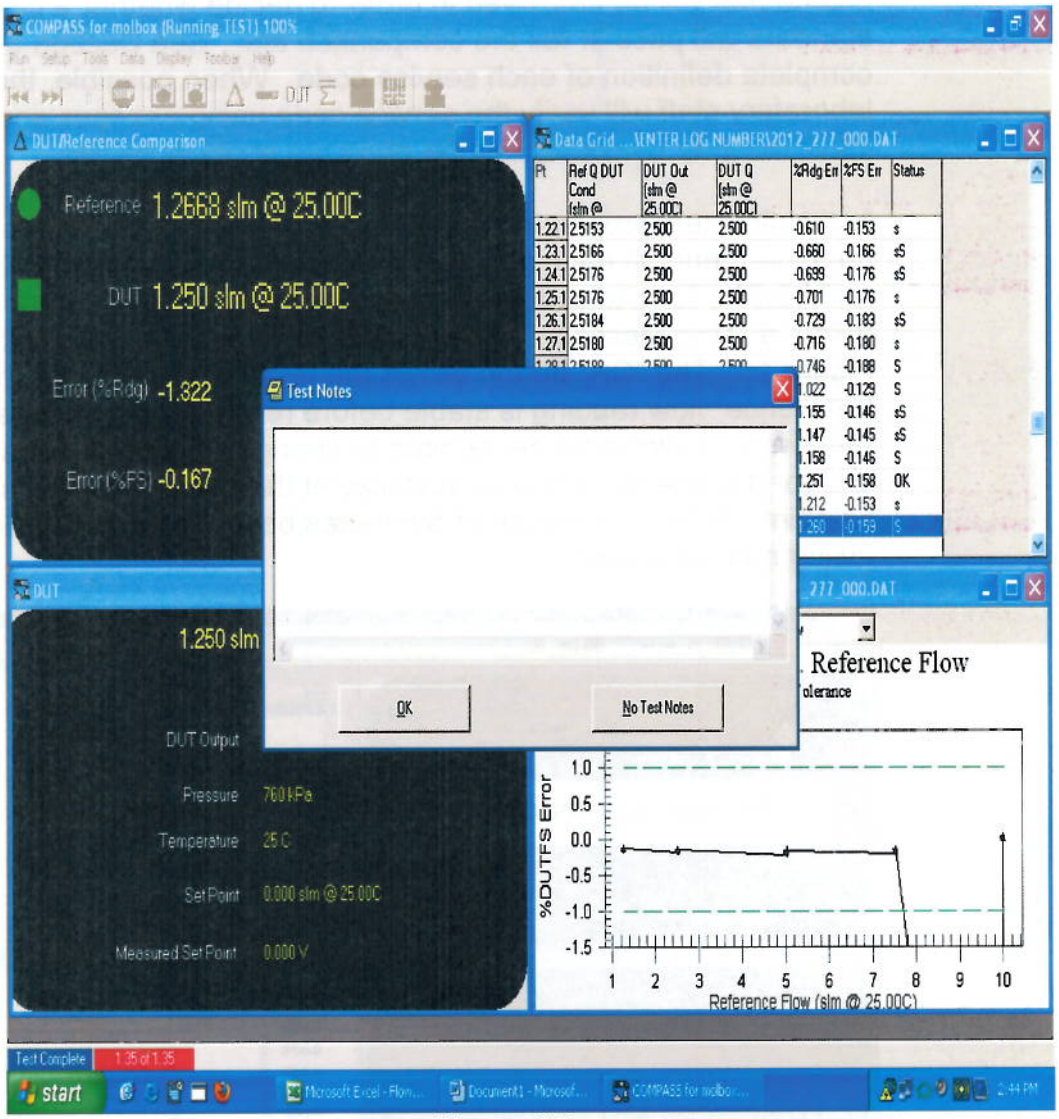


Figure 17

12.3.19 The "Test Complete" window allows you to generate a "COMPASS – Calibration Test Report". Click on the "Generate Report" button. See Figure 18.

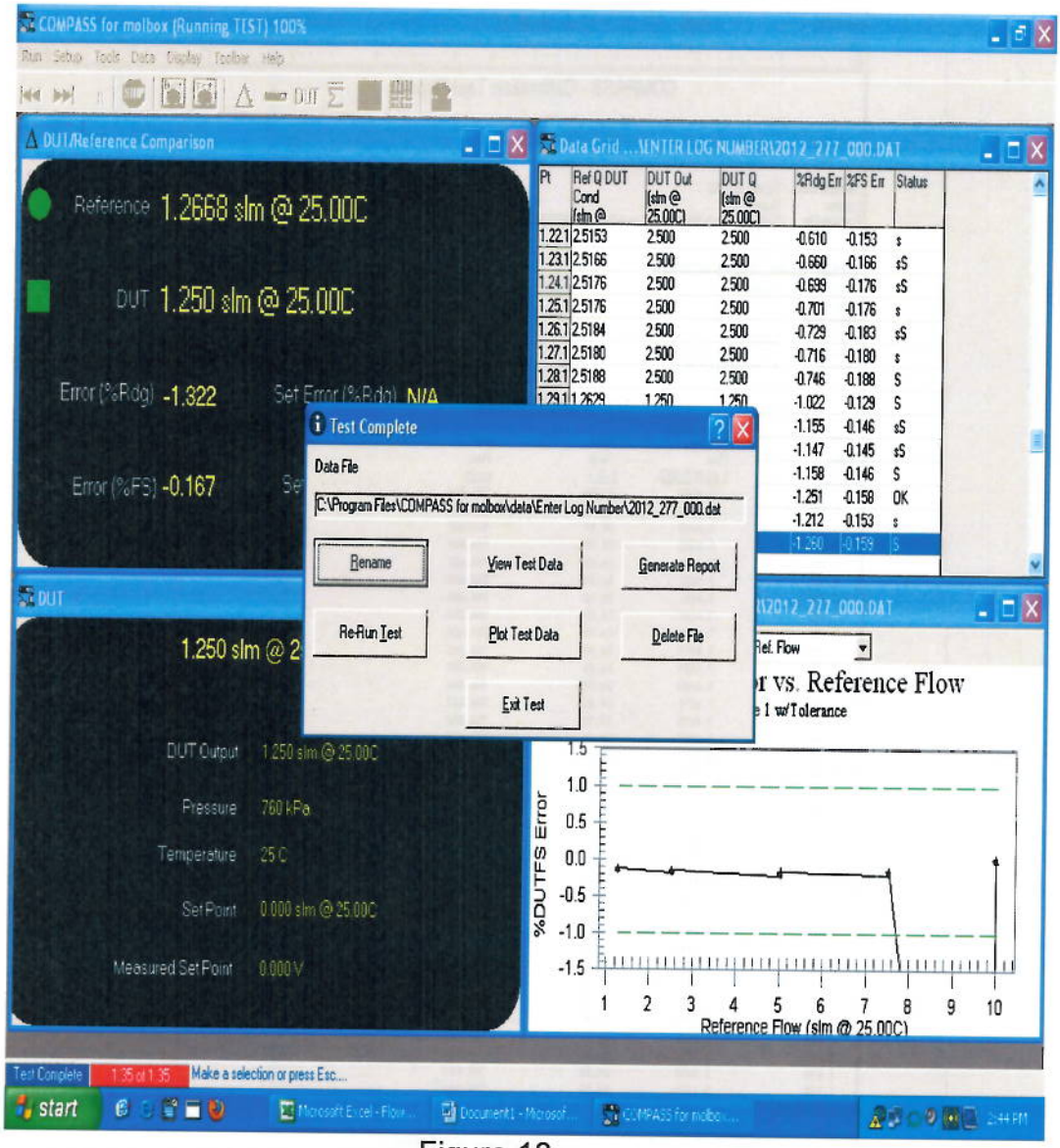
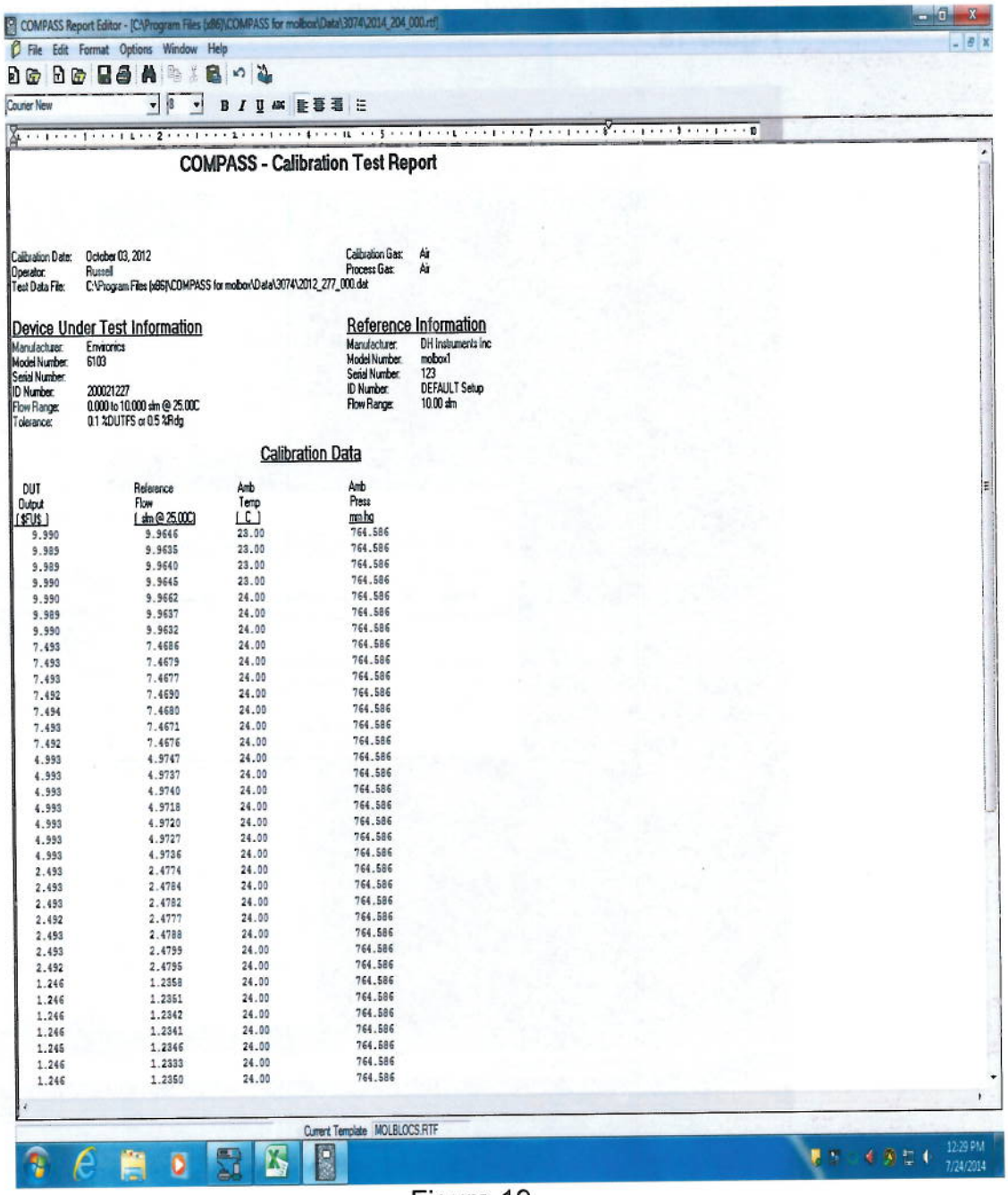


Figure 18

12.3.20 Save and print the "COMPASS – Calibration Test Report". See Figure 19.



COMPASS Report Editor - [C:\Program Files (x86)\COMPASS for molbox\Data\3074\2014_204_000.rtf]

File Edit Format Options Window Help

Couner New

COMPASS - Calibration Test Report

Calibration Date: October 03, 2012
Operator: Russell
Test Data File: C:\Program Files (x86)\COMPASS for molbox\Data\3074\2012_277_000.dat

Calibration Gas: Air
Process Gas: Air

Device Under Test Information

Manufacturer: Environics
Model Number: 6103
Serial Number:
ID Number: 200021227
Flow Range: 0.000 to 10.000 slm @ 25.00C
Tolerance: 0.1 %DUTFS or 0.5 %Rdg

Reference Information

Manufacturer: DH Instruments Inc
Model Number: molbox1
Serial Number: 123
ID Number: DEFAULT Setup
Flow Range: 10.00 slm

Calibration Data

DUT Output [%FUS]	Reference Flow [slm @ 25.00C]	Amb Temp [C]	Amb Press mm hg
9.990	9.9646	23.00	764.586
9.989	9.9635	23.00	764.586
9.989	9.9640	23.00	764.586
9.990	9.9645	23.00	764.586
9.990	9.9662	24.00	764.586
9.989	9.9637	24.00	764.586
9.990	9.9632	24.00	764.586
7.493	7.4686	24.00	764.586
7.493	7.4679	24.00	764.586
7.493	7.4677	24.00	764.586
7.492	7.4690	24.00	764.586
7.494	7.4680	24.00	764.586
7.493	7.4671	24.00	764.586
7.492	7.4676	24.00	764.586
4.993	4.9747	24.00	764.586
4.993	4.9737	24.00	764.586
4.993	4.9740	24.00	764.586
4.993	4.9718	24.00	764.586
4.993	4.9720	24.00	764.586
4.993	4.9727	24.00	764.586
4.993	4.9736	24.00	764.586
2.493	2.4774	24.00	764.586
2.493	2.4784	24.00	764.586
2.493	2.4782	24.00	764.586
2.492	2.4777	24.00	764.586
2.493	2.4788	24.00	764.586
2.493	2.4799	24.00	764.586
2.492	2.4795	24.00	764.586
1.246	1.2358	24.00	764.586
1.246	1.2351	24.00	764.586
1.246	1.2342	24.00	764.586
1.246	1.2341	24.00	764.586
1.245	1.2346	24.00	764.586
1.246	1.2333	24.00	764.586
1.246	1.2350	24.00	764.586

Current Template MOLBLOCS.RTF

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Figure 19

12.3.21 Press "Ctrl-A" to highlight the COMPASS – Calibration Test Report. Press "Ctrl-C" to copy the report. See Figure 20. Proceed to Step 13.0.

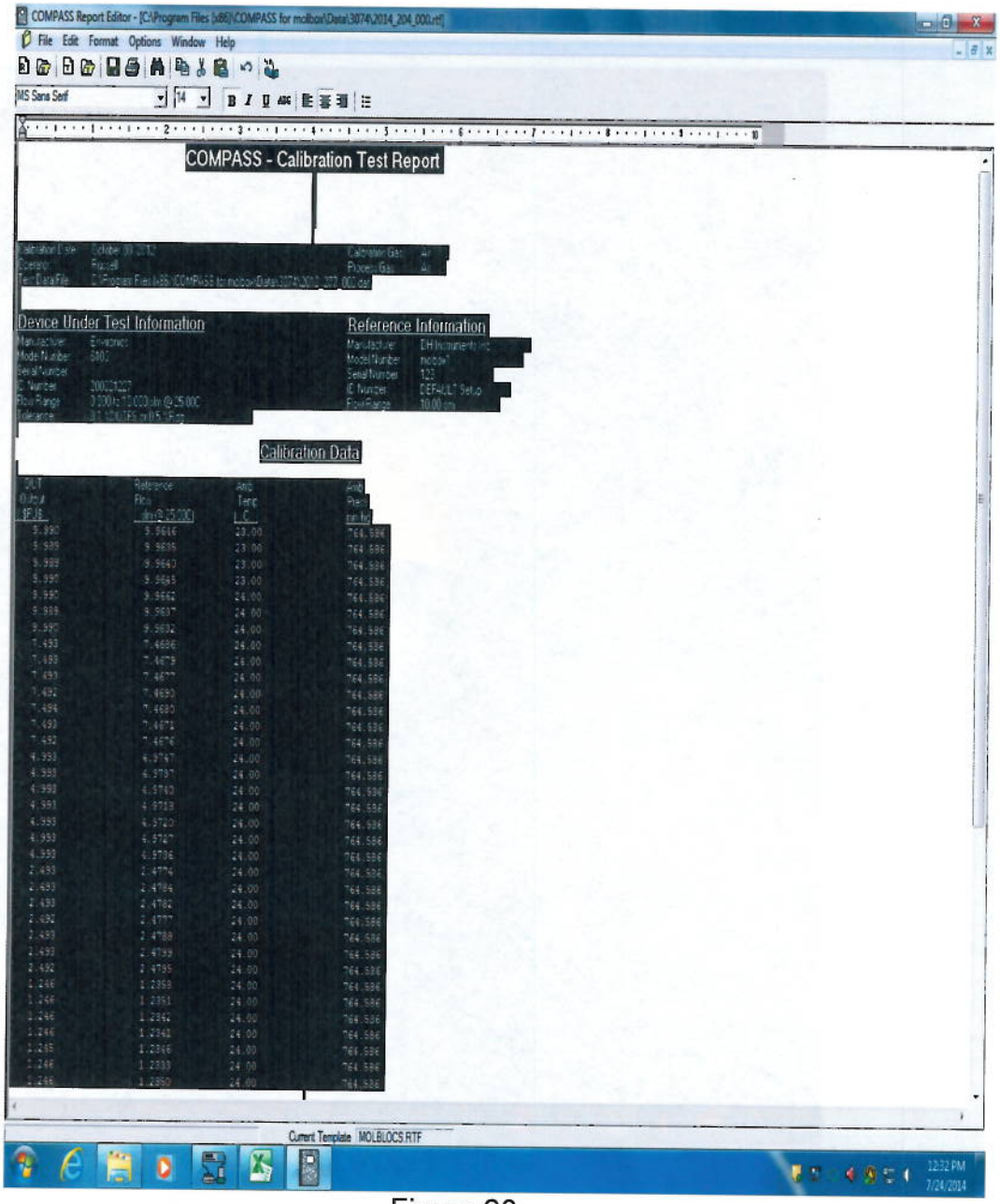

Figure 20

13. 0 Data Entry into IMS and Report Generation

13.1 From any desktop computer in the laboratory click on the "DASPS" icon on the desktop. See Figure 21.

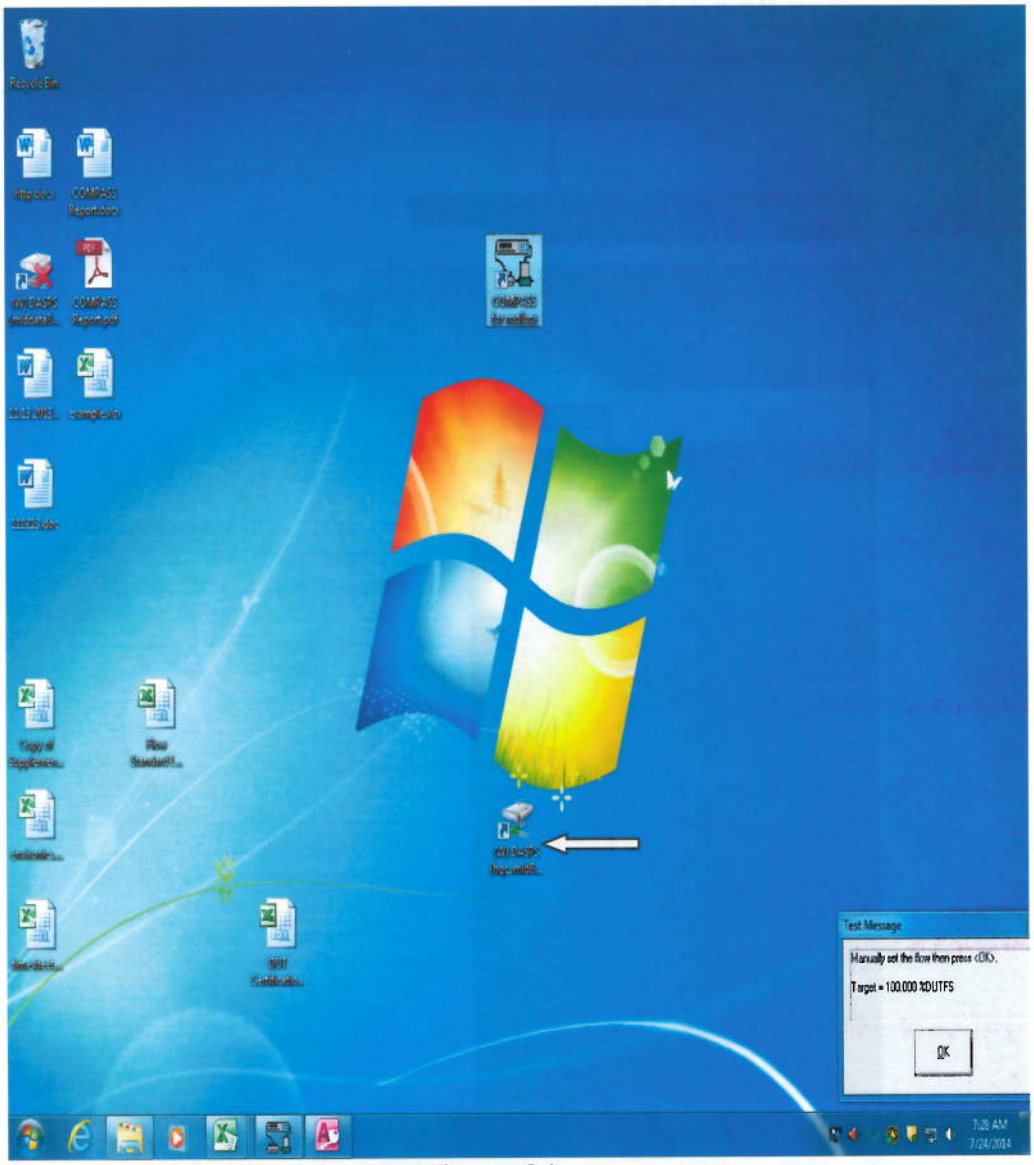

Figure 21

13.1.1 Double-click on the "Standards Laboratory" folder. See Figure 22.

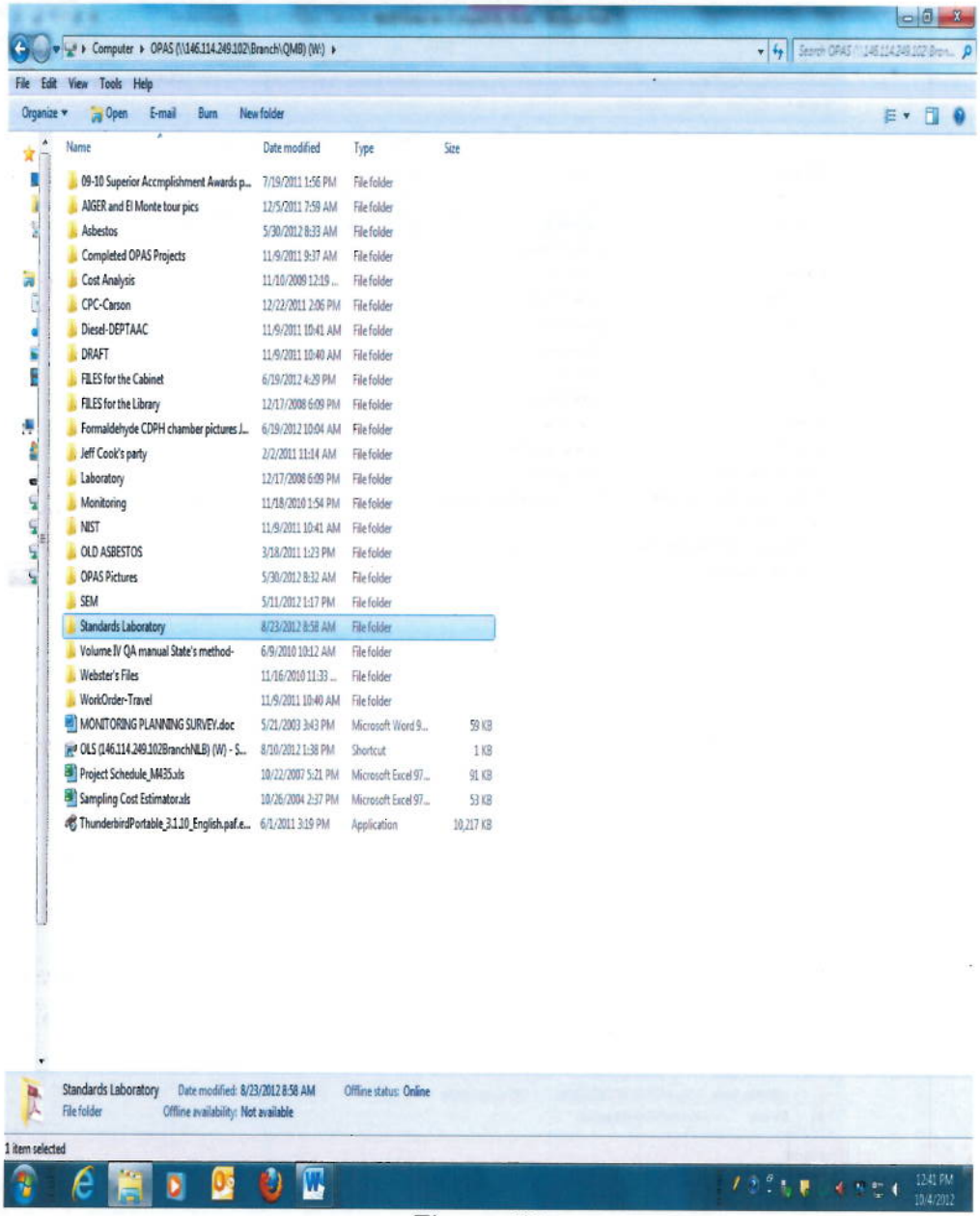

Figure 22

13.1.2 Double-click on the "Calibration Forms" folder. See Figure 23.

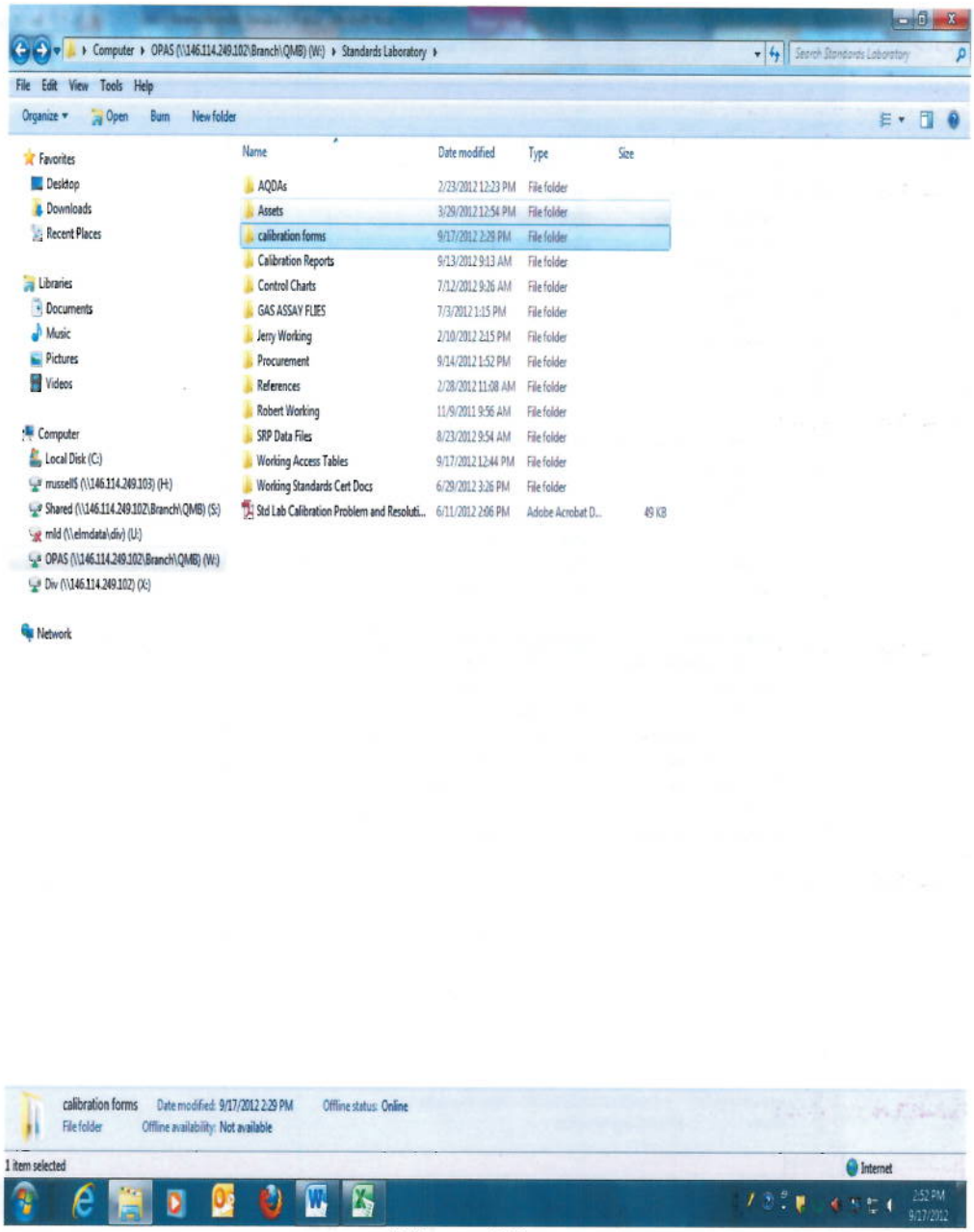

Figure 23

13.1.3 Double-click on the "Flow Cal Data.xlsm" workbook. See Figure 24.

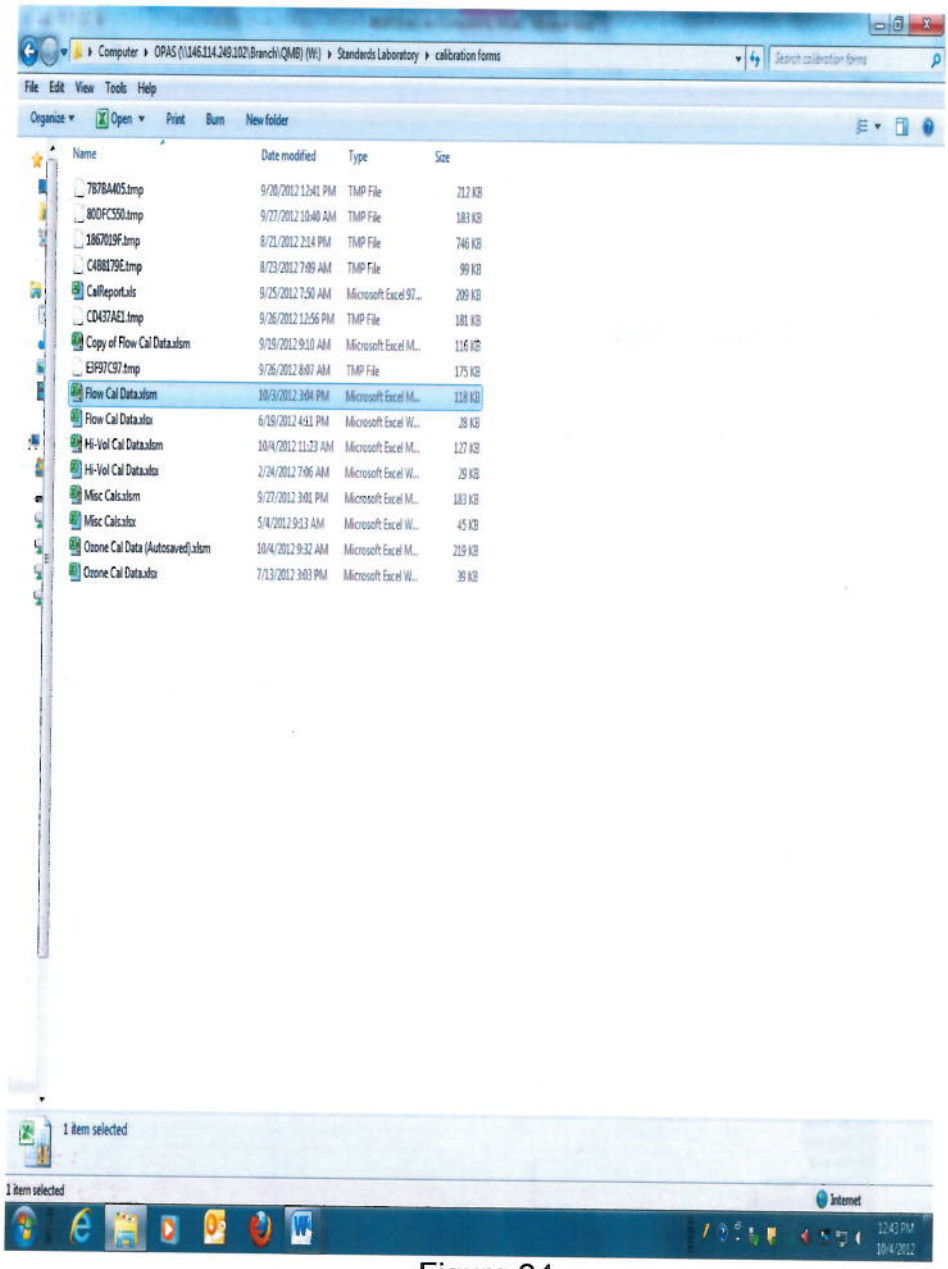

Figure 24

13.1.4 Select the "Compass_ Data" worksheet. See Figure 25. Select the blue highlighted cell (cell A1). Press "Ctrl-v" to insert the COMPASS – Calibration Test Report into the "Compass Data worksheet."

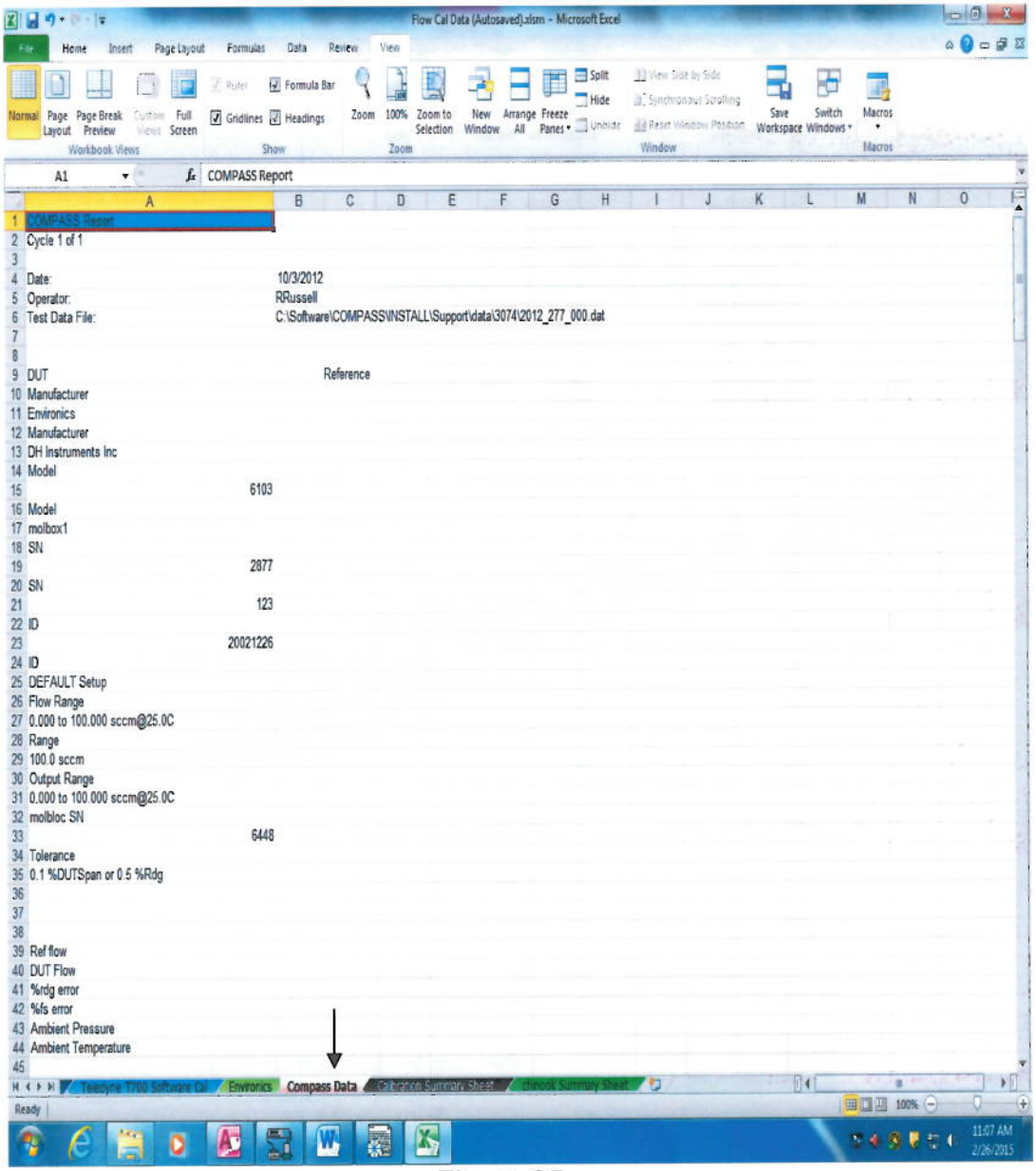

Figure 25

13.1.5 Select the "LOGIN(1)" worksheet. See Figure 26.

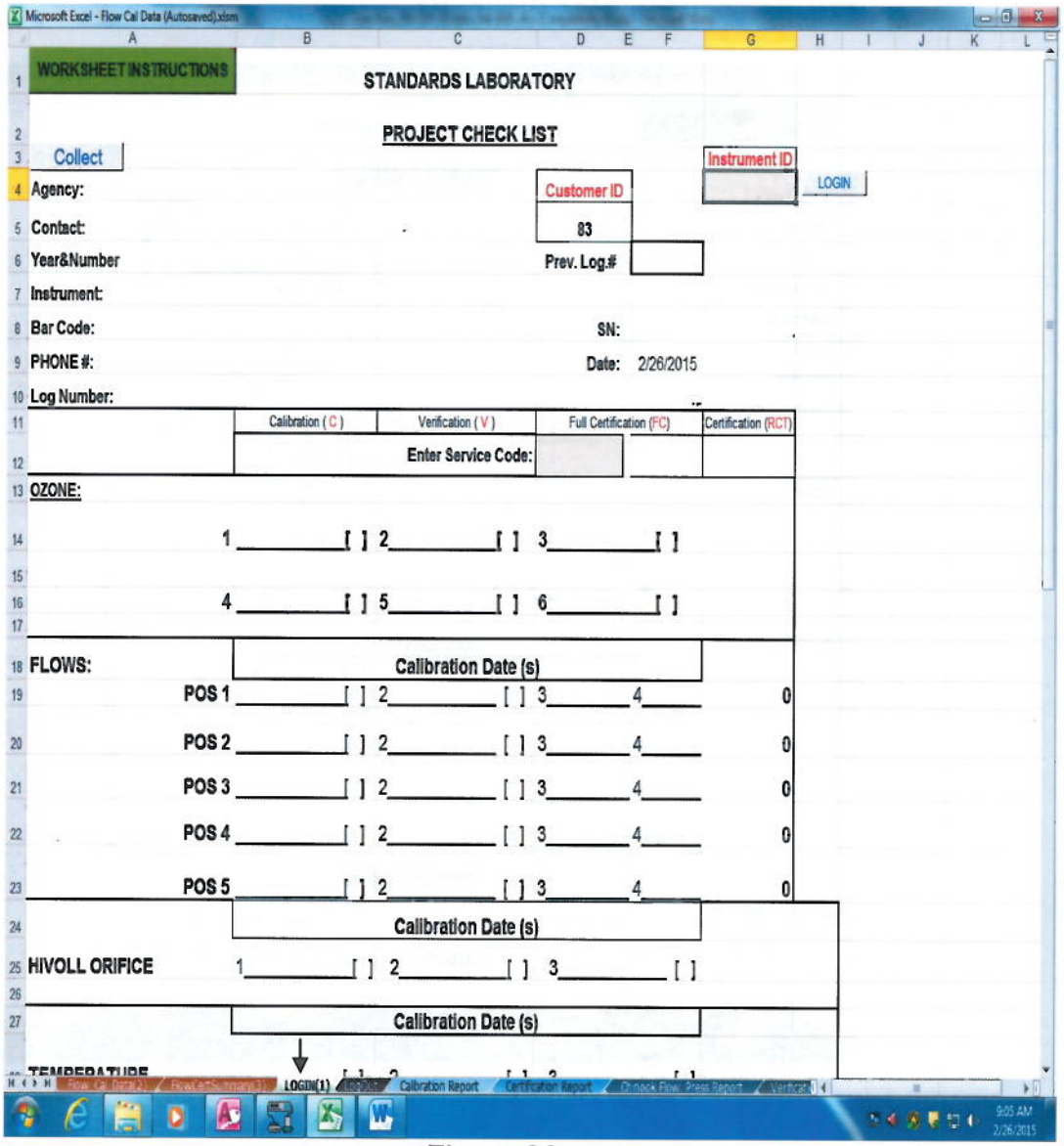

Figure 26

13.1.6 Enter the "Instrument ID" number into cell G4. Enter the service code into cell D12 (C = Calibration, V = Verification, FC = Full Certification, RCT = ReCertification). See Figure 27.

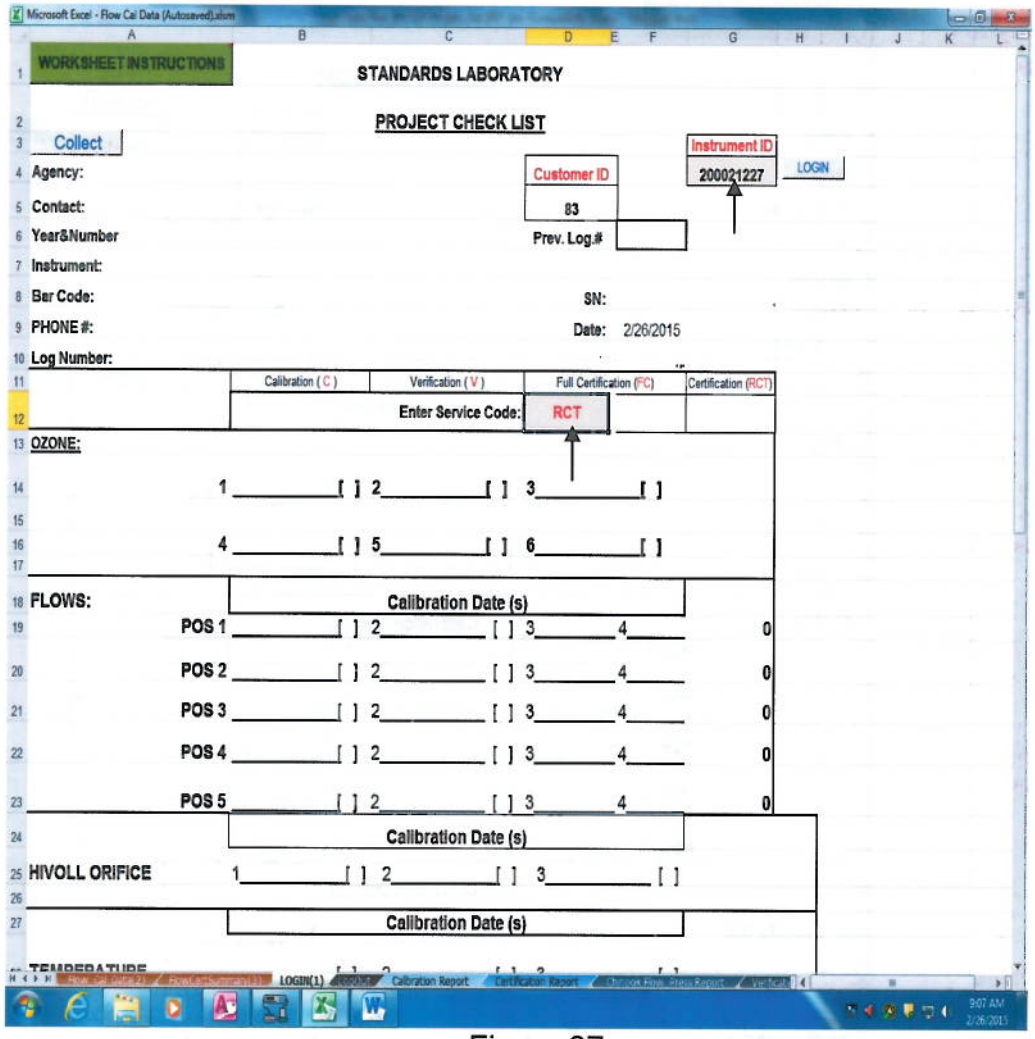

Figure 27

13.1.7 Click on the "Collect" button in the upper left-hand corner. Clicking on the Collect button will populate the worksheet with information about the Agency, Instrument and the Previous log number. See Figure 28.

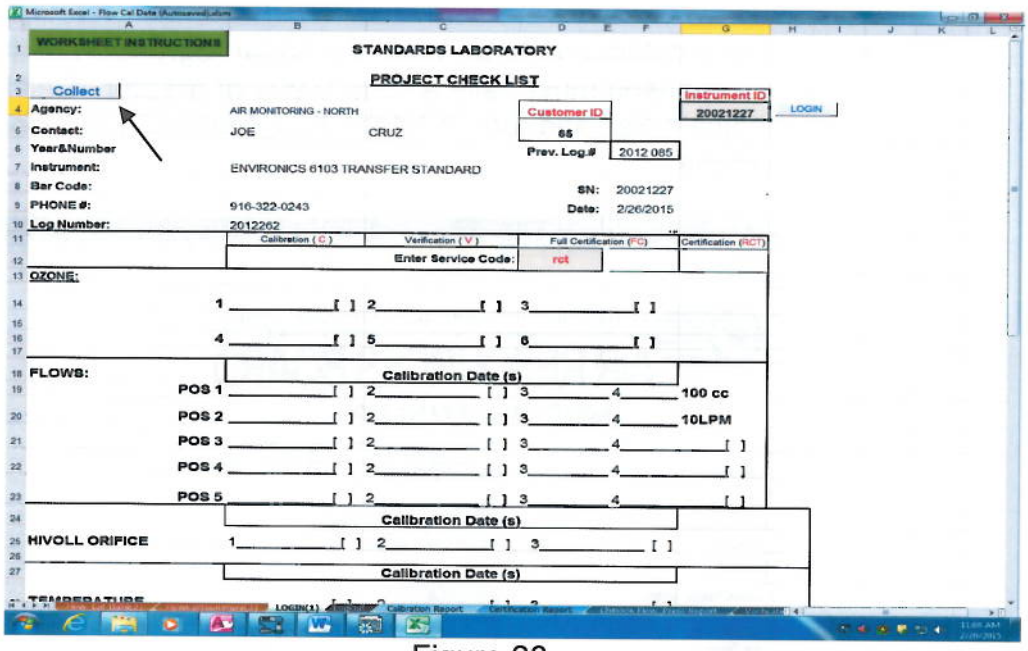

Figure 28

Check to make sure that the Compass data was pasted into the correct cell location in the "Compass Data" worksheet.

13.1.8 Select the "Flow_Cal_Data(2)" worksheet. Enter the "Ambient Pressure (mmhg)" into cell D14 and the "Position Number" into cell D15. See Figure 29.

Depending on the type of test, the following criteria must be met:

- For a verification to be valid, the linear regression of the comparison must have a R^2 of 0.9999 or greater. Cell D45 will indicate Fail and turn red if the flow device did not meet the R^2 criteria.

- For a certification to be valid, the linear regression of the comparison must have a R^2 of 0.9999 or greater. Cell F37 will indicate Fail and turn red if the flow device did not meet the R^2 criteria.

- For a calibration to be valid, the linear regression of the comparison must have a R^2 of 0.999 or greater. Cell F37 will indicate Fail and turn red if the flow device did not meet the R^2 criteria.

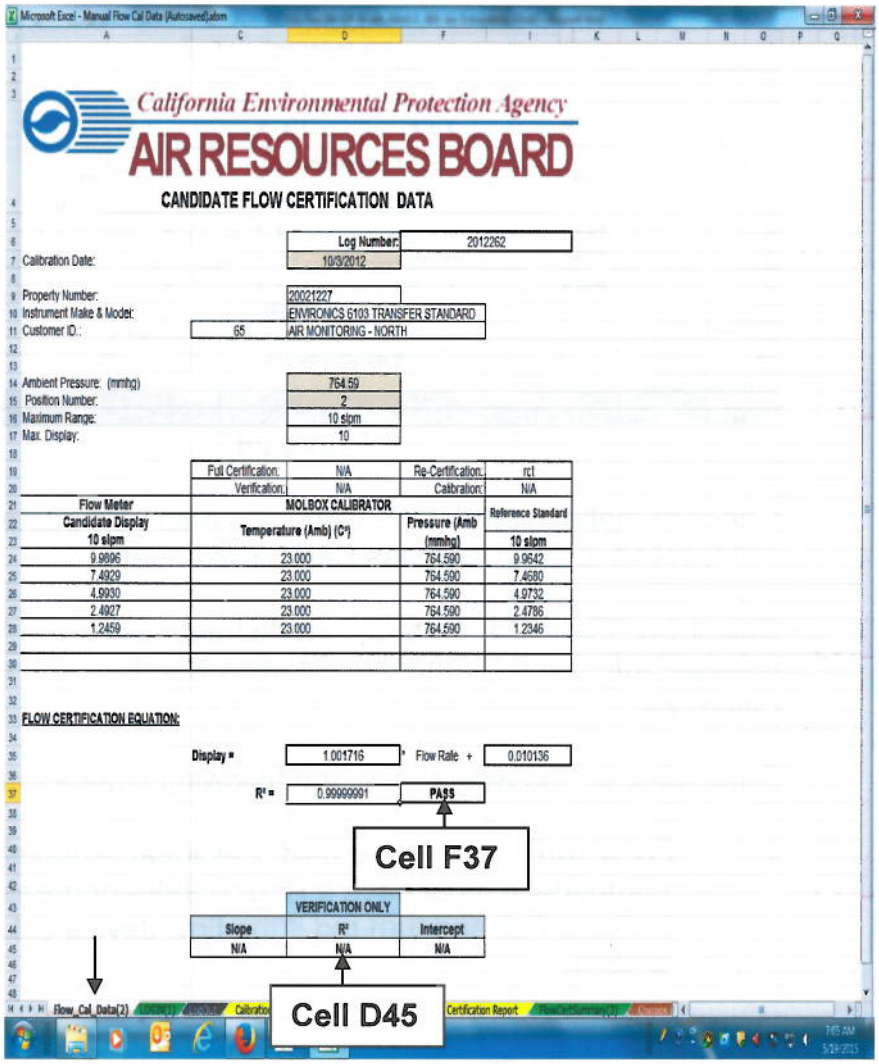

Figure 29

13.1.9 Select the "FlowCertSummary (3)" worksheet. See Figure 30.

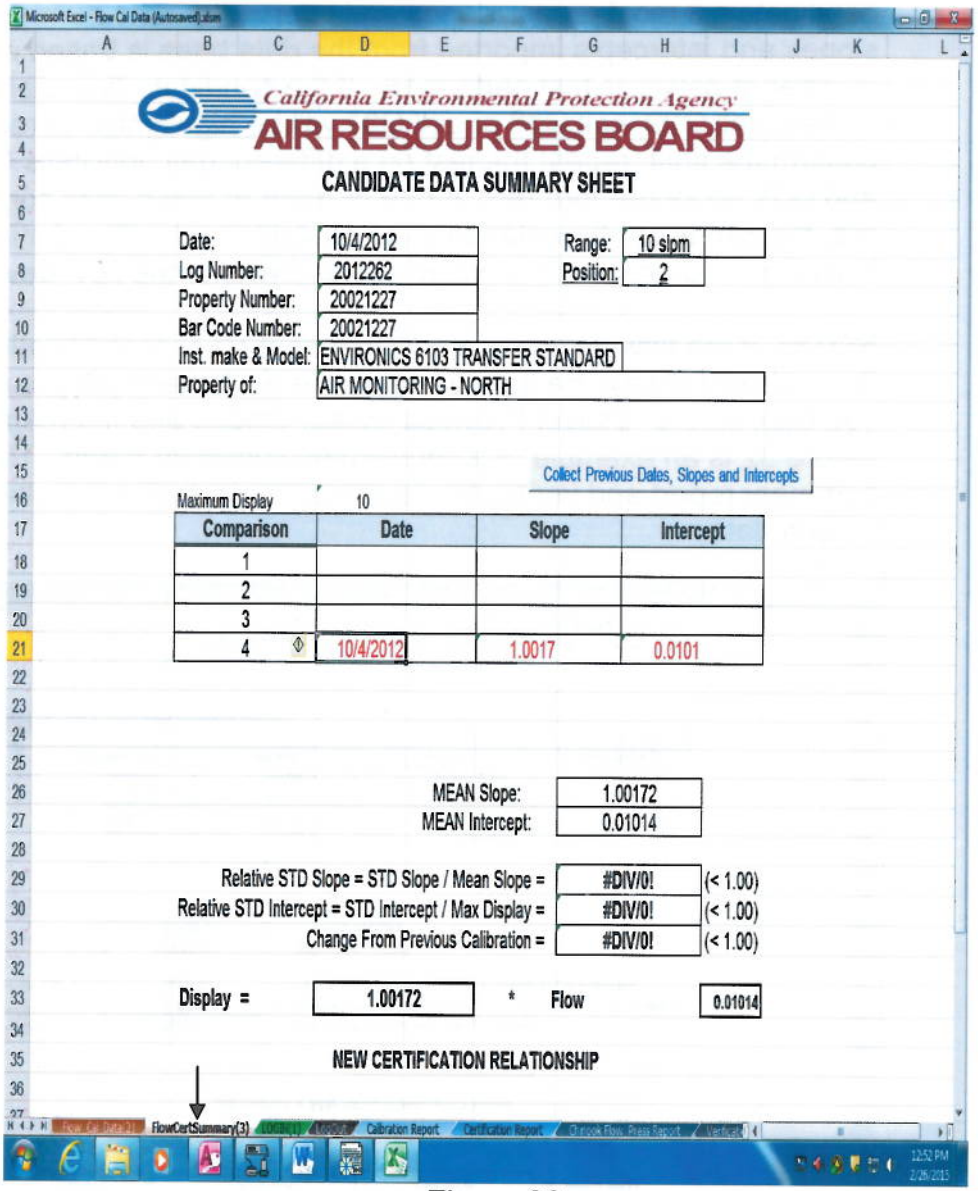

Figure 30

13.1.10 Click on the "Collect Previous Dates, Slopes and Intercepts" button. See Figure 31. Clicking on this button will populate the worksheet with the candidate's 3 most recent slopes and intercepts. The number of previous slopes and intercepts imported from the data base is based on the number of previous test performed. If the candidate flow standard has shifted, cell G29, cell G30 or cell G31 will be highlighted in red. To confirm the shift, repeat the test on a different day until cells G29, G30 and G31 no longer turn red. If one or more of these cells continue to turn red, the candidate flow standard is not stable and a Standard Failure Notice should be must submitted to the owner of the flow device.

NOTE: If the flow device is a certification (FC) or recertification (RCT), there should always be 3 previous slopes and intercepts populated when you click on the "Collect Previous Dates, Slopes and Intercepts" button. Figure 32 is an example of a certification summary report. The calibration summary report and verification summary report will not include 1% shift criteria data.

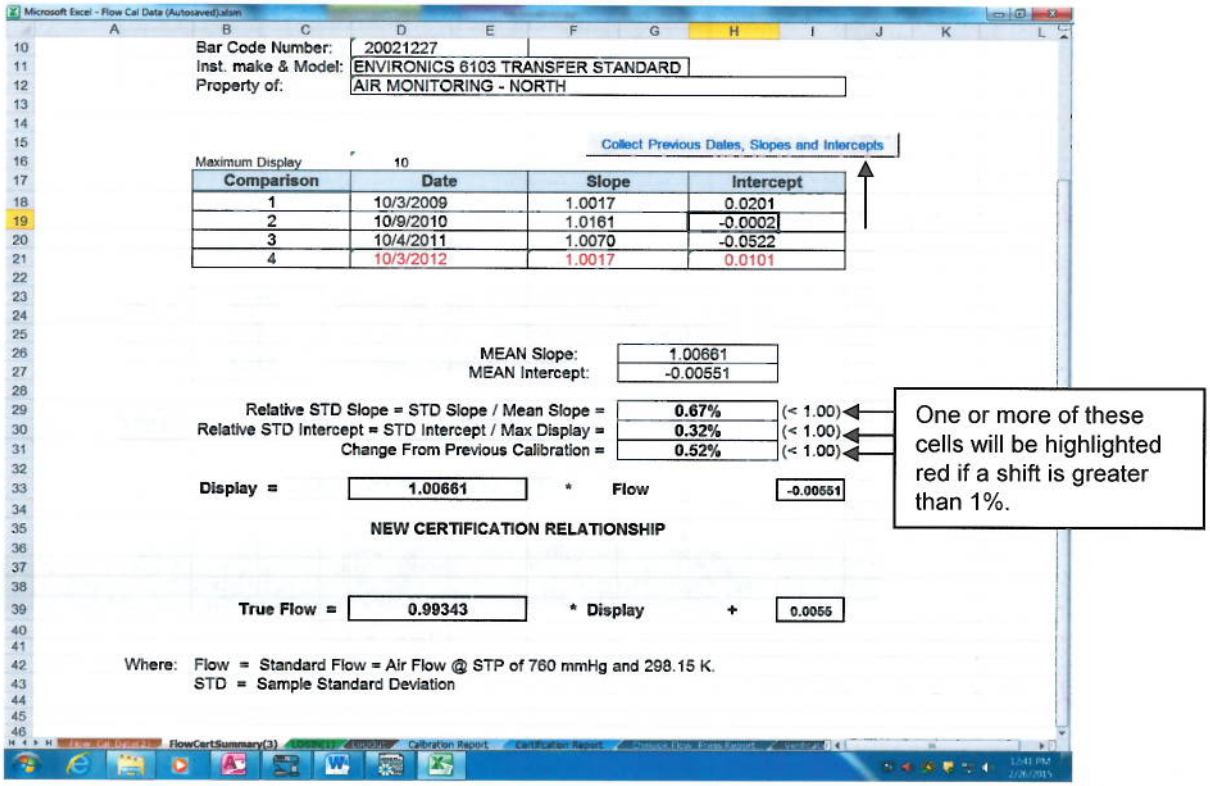

Figure 31

13.1.11 If there are no red highlighted cells, select the appropriate report for the type of service performed. The options are: Calibration report, Certification report, Verification report, and Chinook Flow Press Report. See Figure 32. Evaluate each worksheet for accuracy and completeness. Print the Flow_Cal_Data (2) worksheet, FlowCertSummary (3) worksheet and the appropriate report for the type of service performed. Save the workbook and have a peer review all documents associated with this test.

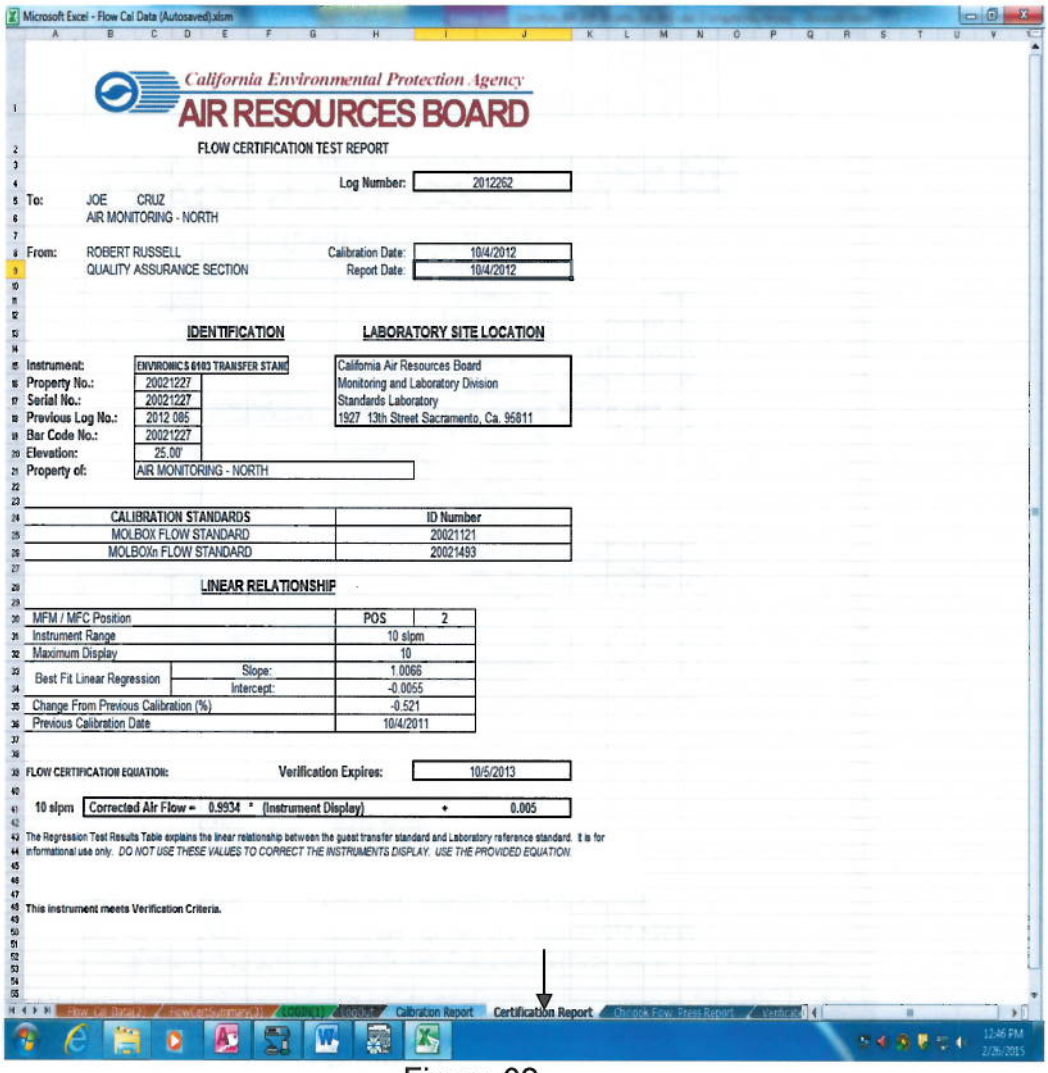

Figure 32

14.0 Electronic Filing of Calibration Data

14.1 Click on the "Acrobat" tab then click "Create PDF."

Add Summary Sheet and Certification Report to "Sheet in PDF." See Figure 33.

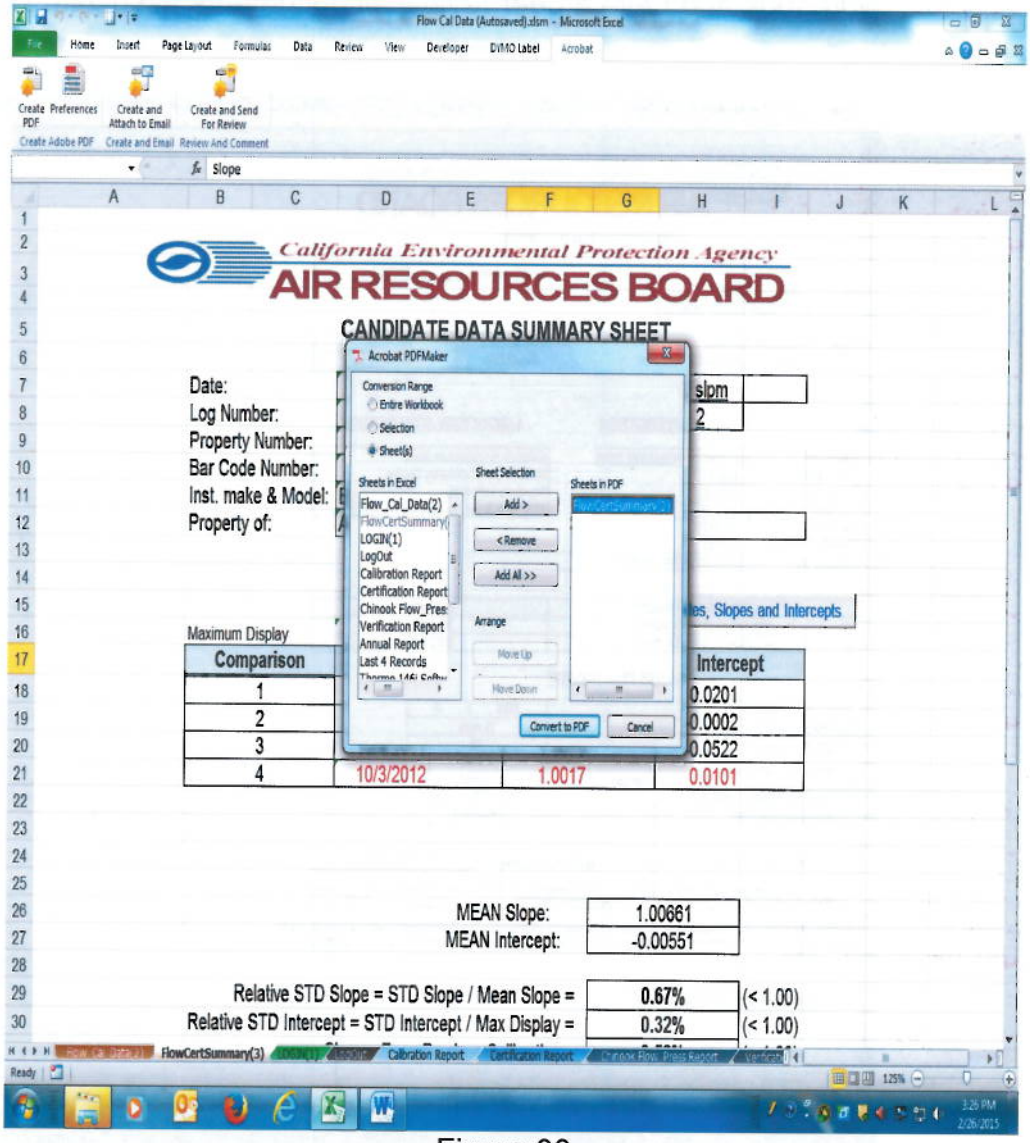

Figure 33

14.2 Click on the "Convert to PDF" button. See Figure 34.

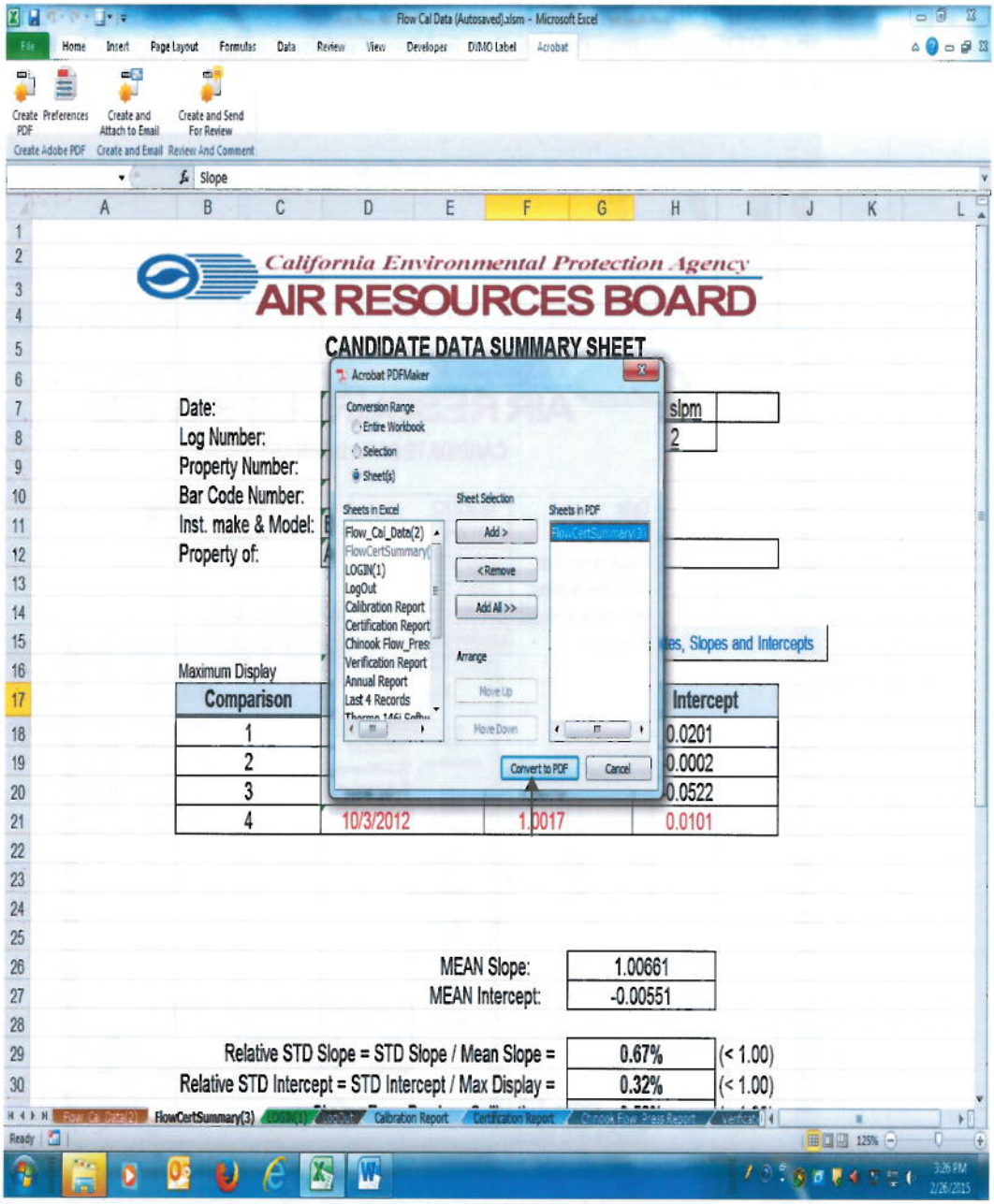

Figure 34

14.3 Each device is assigned an ID number or barcode number. A folder has been created with the barcode number. These folders are located in the following location: W:\Standards Laboratory\Calibration Reports. Save the PDF documents in the folder that is assigned to the candidate. See Figure 35.

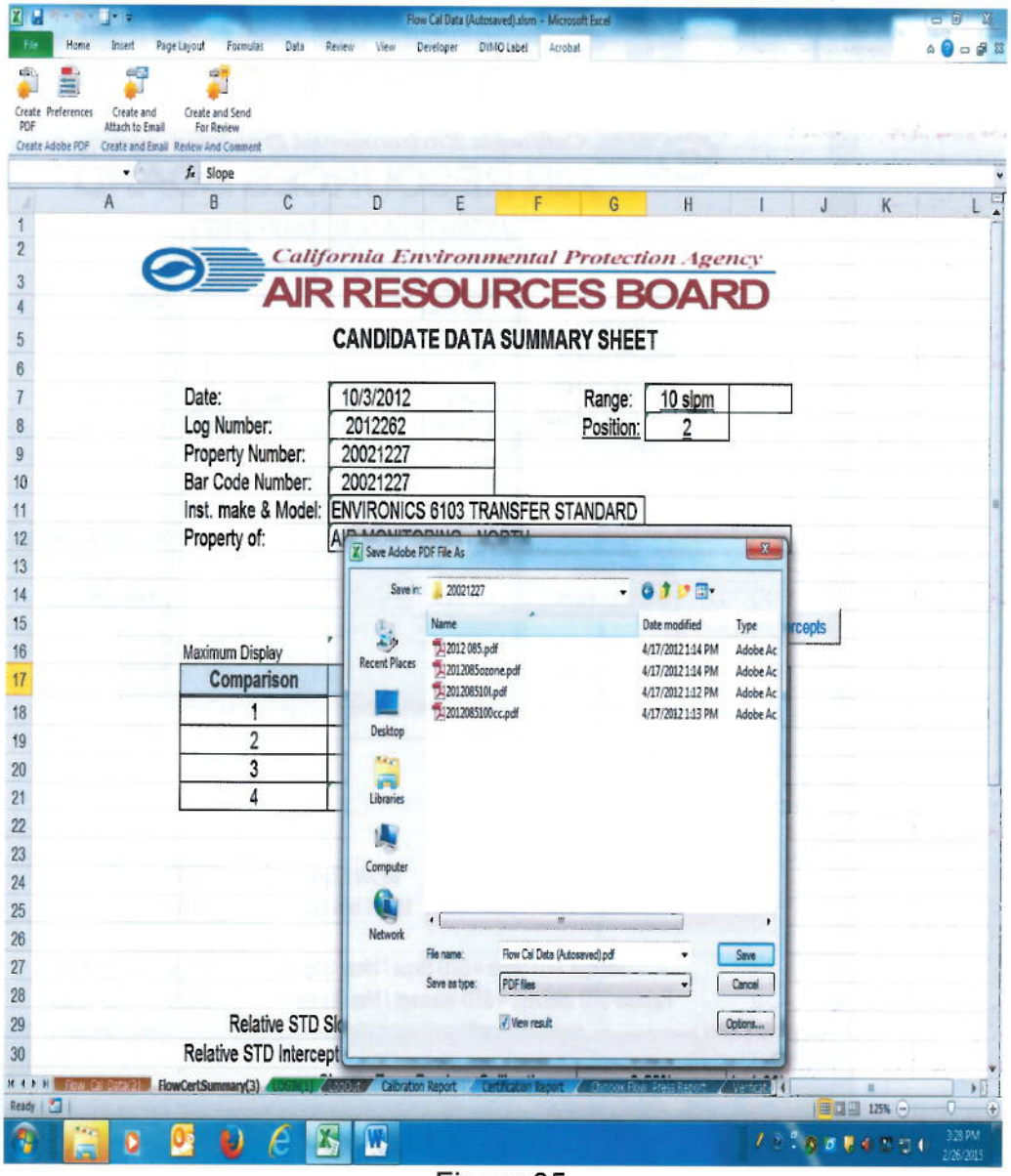

Figure 35

15.0 Quality Control

- When a molbloc cross check verification exceeds 2 standard deviations of the mean slope a warning is triggered. A warning initiates an investigation of the process, but does not stop the process.

- When a molbloc cross check verification exceeds 3 standard deviations of the mean slope an action is triggered. This action involves stopping and investigating the process, and review of any data that may have been effected. If warranted, instruments may be recalled from field use for reanalysis.

- The Molbox1 control unit is sent back to the manufacturer (Fluke Calibrations Instruments, Inc.) bi-annually to have the Reference Pressure Transducers (RPT) and Analog inputs tested and NIST certified.

- The Molbox Control Ohmic Measurement System is verified annually. Refer the Molbox1 Molbloc Terminal (Ver. 5.00 and Higher) Operation and Maintenance Manual, page 143.

- System leak checks are performed on all working flow standard and the candidate's standards before each calibration. Refer the Molbox1 Molbloc Terminal (Ver. 5.00 and Higher) Operation and Maintenance Manual, page 48.

- Every six months each Molbloc flow standards is compared against a BIOS DryCal Primary flow rate. Each Molbloc flow standard slope should be less than 1% from true. The comparison results are saved in the laboratory records.

16.0 Troubleshooting

- If a successful leak test was performed and the flow rate seems incorrect, refer to section 6 of the "Molbloc Terminal Operation and Maintenance Manual."

- Consult with lead staff if further assistance is required.

17.0 References

- U.S. EPA Quality Assurance Handbook Volume II, Sec.12.
- U.S. EPA Quality Assurance Guidance Document 2.12 (Monitoring PM2.5 in Ambient Air Using Designed Reference or Class I Equivalent Methods).
- Code of Federal Regulations (CFR), title 40, part 50 App J and L
- Engineered Mounting System for molbloc-S Mas Flow Elements Operation and Maintenance Manual.
- COMPASS for Molbox Flow Calibration Software User's Manual.
- Molbox1 molbloc Terminal (Ver. 5.00 and Higher) Operational and Maintenance Manual.

18.0 Diagrams

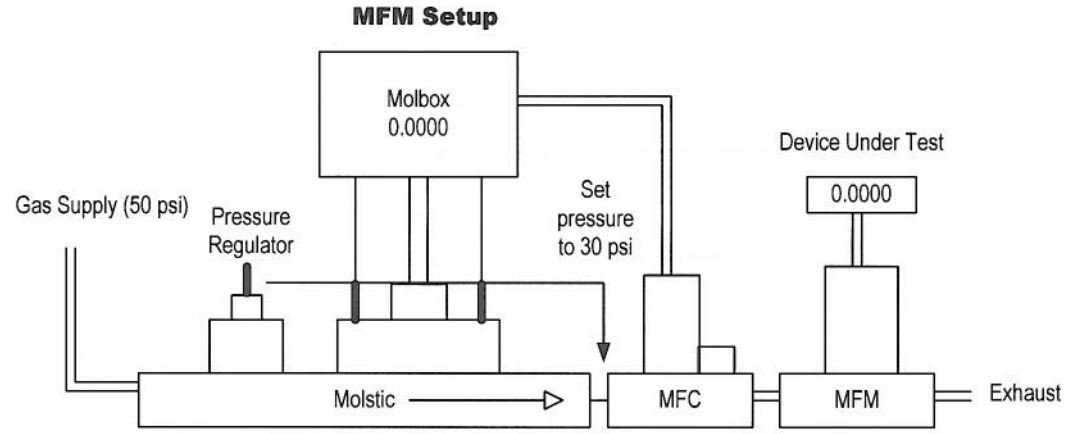

Diagram 1

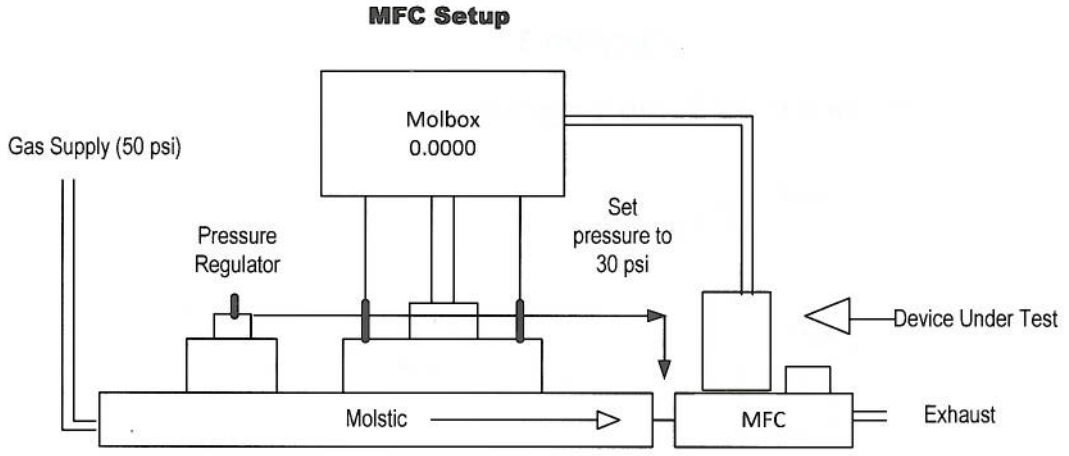

Diagram 2

18.1 Tanabyte 300T Setup Diagram

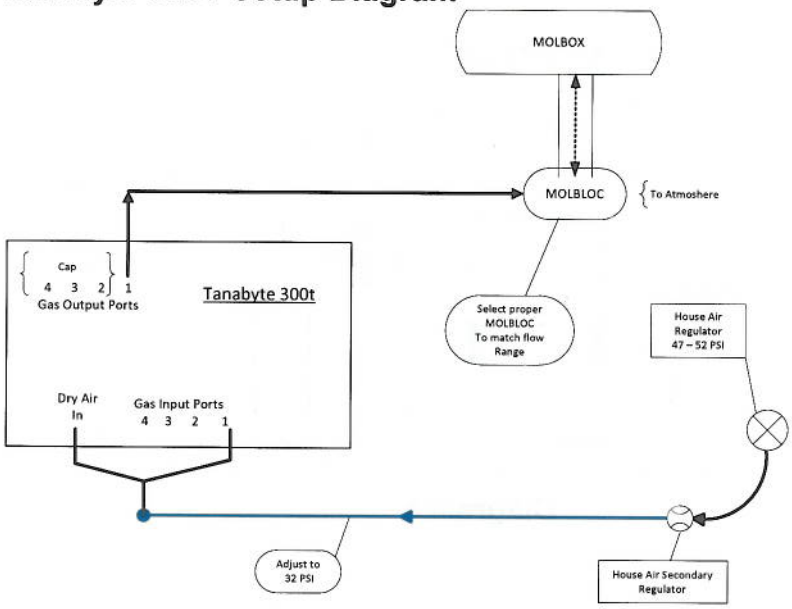

Diagram 3

18.2 Environics 6103 Setup Diagram

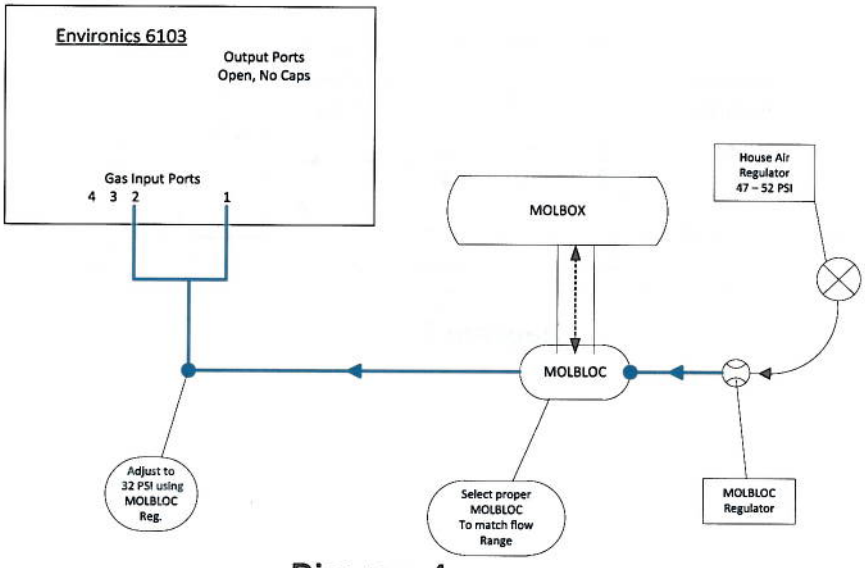

Diagram 4

18.3 DeltaCal Primary Flow Standard Setup Diagram

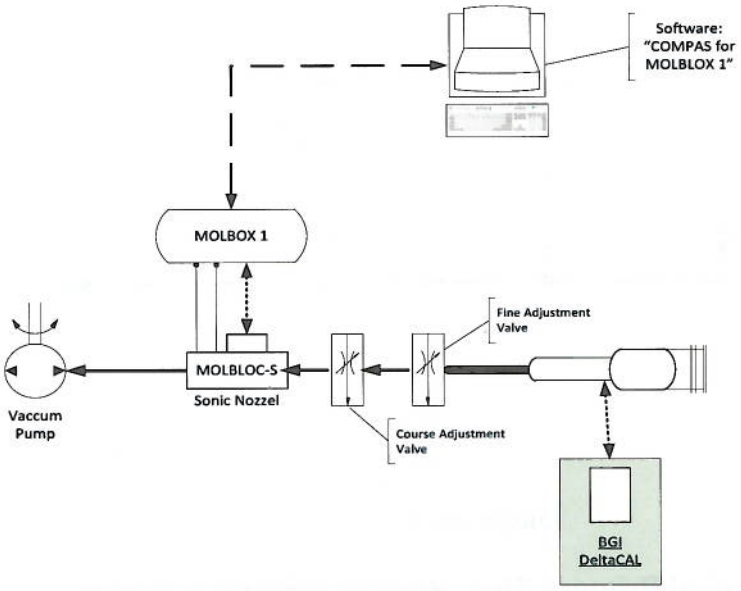

Diagram 5

18.4 BGI TriCal Primary Flow Standard Setup Diagram

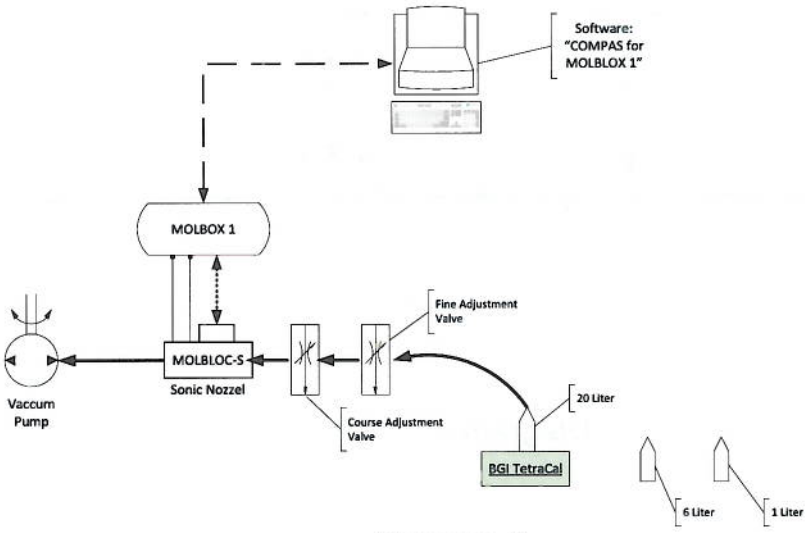

Diagram 6

18.4 Gilibrator Primary Flow Standard Setup Diagram

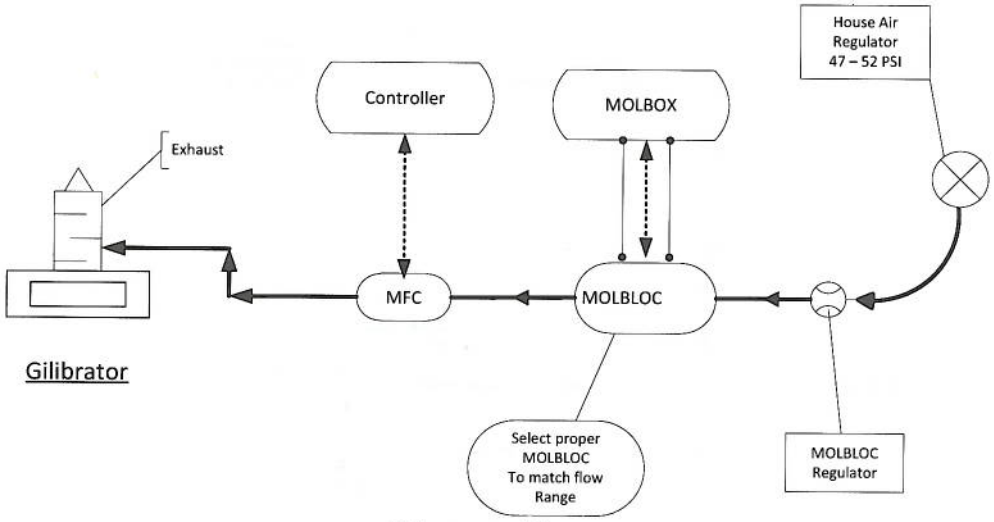

Diagram 7

18.5 Bios DryCal Primary Flow Standard Setup Diagram

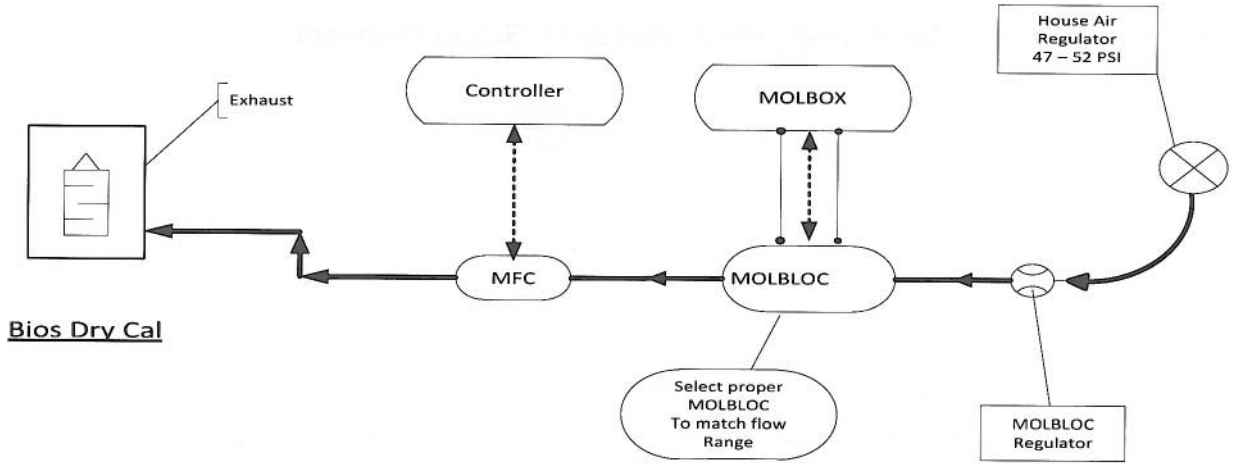

Diagram 8